SEPTEMBER 3, 1959

MACHINE DESIGN

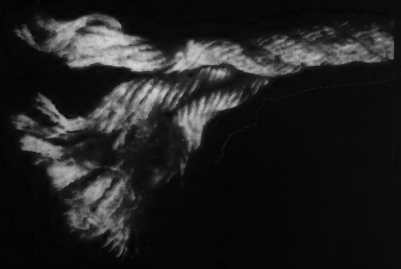
A PENTON PUBLICATION — BIWEEKLY

Which System . . . Hydraulic or Pneumatic?

Contents, Page 3

Photograph:

NO HOLDING US BACK!



It's all behind us now — a year of recession intensified by our first serious labor dispute — but there was no holding us back! Here's what we have accomplished to serve you better in the "soaring 60's."

A new midwestern plant fully equipped with the most advanced machinery for the mass production of your special bearings and parts.

Modernization and expansion of facilities at our main plant in New Jersey.

Establishment of our new Field Engineering Division whose expert advice and assistance in the design, engineering and application of your every powder metallurgy requirement will assure you of the finest service in the industry.

And, as always, . . .

Buy Bound Brook for the finest quality and service at sound prices.

BOUND BROOK

BOUND BROOK OIL-LESS BEARING CO., ESTABLISHED 1883

Pioneer in

POWDER METALLURGY BEARINGS + PARTS

BOUND BROOK, N. J. and now PLANT #2 STURGIS, MICH.

METAL SAWS • LATHES

GRINDERS • OVERHEAD CRANES

MECHANICAL PRESSES

INDUSTRY'S MODERN, PRECISION MACHINES GET

SAFE ACCURATE INSTANT LUBRICATION...

WITH ALEMITE ACCUMATIC® CENTRALIZED SYSTEM

While you're in the design stage—remember that no machine, no matter how simple or complicated its function, is really modern unless it is equipped with an automatic lubrication system.

Machines with multiple bearings or dangerously located bearings need lubrication from one central point in seconds. Vital high-precision lubrication at all times. And *they'll get just that*—with an Alemite Centralized System. Accumatic valves in this system are specially designed to provide an accurate quantity of lubricants to all machine bearings while the machine is in operation. With fluid oils and lighter greases of N.L.G.I. No. 1 rating.

Tests of the Alemite Accumatic Centralized System show no appreciable variation in the amount of lubrication discharged after 73,312 cycles—*the equivalent of 122 years of twice a day lubrication service.*

AN ACCUMATIC SYSTEM OFFERS ALL THESE ADVANTAGES:

- Prevents application of wrong lubricant.
- Seals completely against dirt, grit, water.
- No parts are neglected—lubricates inaccessible and dangerous bearings.
- Eliminates product spoilage due to over-lubrication.
- Services all bearings in one operation.
- Delivers exact amount of lubricant to bearing.

Write for Alemite Accumatic catalog!

Dept. BB-99
1850 Diversey Parkway
Chicago 14, Illinois

Symbol of SW Excellence

ALEMITE DIVISION
STEWART-WARNER CORPORATION

←Circle 401 on Page 19

Circle 404 on Page 19

IT'S ICE-SLICK

Won't Stick at 30° Below

Try C/R K-400 Cups for Smoother Power Cycles

Any time you face the problem of reducing cylinder cup breakaway or sliding friction, chattering or freezing, come see us. We're reasonably certain that Chicago Rawhide's Sirvis Leather K-400 cups can help you. Their specialty is easy sliding — particularly in vacuum cylinders at sub-zero temperatures and in pneumatic cylinders at ambient temperatures and low pressures. Tests show a 50% reduction in breakaway and sliding friction over standard leather cups at ambient temperatures . . . and these K-400 cups are functioning beautifully in applications at -30° F. In another test, C/R Sirvis K-400 cups were run well over one million cycles at 20″ of vacuum with negligible leakage and wear.

So if you are trying to design a new, smooth-working, low-friction pneumatic cylinder — or take the bugs out of an old one — jot down C/R K-400 cups and call us.

CHICAGO RAWHIDE MANUFACTURING COMPANY

SIRVIS DIVISION, 1221 ELSTON AVENUE • CHICAGO 22, ILLINOIS

Offices in 55 principal cities. See your telephone book.

In Canada: Chicago Rawhide Mfg. Co. of Canada, Ltd., Brantford, Ontario

Export Sales: Geon International Corp., Great Neck, New York

C/R PRODUCTS: C/R Shaft & End Face Seals • Sirvene (synthetic rubber) molded pliable parts • C/R Non-metallic gears

C/R

Front Cover: Check valves—common fluid-power components—are used by George Farnsworth to illustrate the problem of deciding whether to choose an air or oil system. Article on the same subject by I. Leonard Kaplan starts on Page 122.

September 3, 1959

Heat's on Big Tires 24

News Report—What's being done in tire design and research to cope with mounting performance demands from off-the-highway vehicles.

Which System—Hydraulic or Pneumatic? 122

I. LEONARD KAPLAN—Factors that influence selection of the right working medium in fluid-powered systems: Space, fluid medium, environment, economics, components.

Protection Against Patent Infringement 133

ALBERT WOODRUFF GRAY—How the rights of a patent owner can be affected by overlong delay in taking proper action against infringers.

Planetary Genevas 135

LEIF ARNESEN—Design details and performance characteristics of a unique Geneva drive system which uses a planet gear to eliminate shock during indexing.

Flexible Cam Mechanisms 140

RAY C. JOHNSON—A simple numerical method for dynamic analysis and design of cam-follower systems with elastic members that deflect appreciably during operation.

Design of Panel Windows 152

FRANK WILLIAM WOOD Jr.—Methods of protecting dials, scales, and pointers from mechanical damage with windows that provide clear visibility.

Precision Barrel Finishing 156

LESTER F. SPENCER—Principles, practices, and limitations of an inexpensive process for producing high surface finishes or burnished effects on small parts.

Optimum Sections of Tubular Columns 161

B. SAELMAN—*Data Sheet*—A simplified procedure for design of minimum-weight round tubular columns without trial-and-error steps.

Porcelain Enamels 165

C. G. BERGERON—*Design Abstract*—Comparative room-temperature and elevated-temperature electrical properties for three types of insulating enamel coatings.

CONTINUED NEXT PAGE

THE PROFESSIONAL JOURNAL FOR ENGINEERS & DESIGNERS

MACHINE DESIGN

September 3, 1959

Volume 31 — No. 18

Reward for Responsibility 121

COLIN CARMICHAEL—*Editorial*

Engineering News 6

Steel castings are produced with tensile strength of almost 300,000 psi —ultrasonic equipment keeps missiles clean—DC-8 design emphasizes safety and fatigue life—government proposes awarding medals and cash to outstanding engineers—seven-stage finishing procedure rust-proofs 1960 Chrysler cars—missile-guidance system fixes on earth and sun—experiments may have produced controlled thermonuclear reaction.

Scanning the Field for Ideas 129

Free-floating piston doubles as check valve—"dimpled" conduit surface lets wires be pulled through easily—flow-measuring vane controls fluid bypass—double springs insure positive electrical contact—flowing-grease barrier protects shaft seal from abrasive material—dual-wire construction permits air hose to double as current carrier.

Design in Action 146

Spring functions as rack and pinion—smaller wheels on piggyback flatcars increase loading height—rear suspension is adjustable for one or two passengers—servo motor sets any one of 50 potentiometers.

Tips and Techniques

Light path layout 160

Trends 22

Design Abstracts 165

New Parts and Materials 184

Engineering Department Equipment 219

The Engineer's Library 223

Noteworthy Patents 230

Backtalk 246

Meetings and Shows 44

Helpful Literature 178

Subject Index 17

Reader Service Cards . . 19

Advertising Index 245

Business Staff 245

IN THE NEXT ISSUE: Keeping turbines out of trouble . . . where drafting standards leave off . . . memo to Miss Jones . . . maximum stresses in long cylinders . . . rack planetaries . . . new property values for vulcanized fiber . . . Special Feature—design manual for cast-bronze sleeve bearings

Editor
COLIN CARMICHAEL

Associate Managing Editors
BENJAMIN L. HUMMEL
ROBERT L. STEDFELD

Associate Editors
LEO F. SPECTOR
ROBERT C. RODGERS
WILLIAM S. MILLER
SPENCER R. GRIFFITH

Assistant Editors
FRANCIS A. HUSARIK
CLARE E. WISE
JAMES A. PARKS
THEODORE M. LEACH
STANLEY G. COOK
RICHARD A. JACOBSON
JANE H. SMITH
MARIAN L. EICHAR

Art Editor
FRANK H. BURGESS

Contributing Editor
ROGER W. BOLZ

EDITORIAL OFFICES
Penton Building, Cleveland 13, Ohio

Branch Offices
New York, Detroit, Chicago, Pittsburgh, Washington, London

MACHINE DESIGN is sent at no cost to management, design and engineering personnel whose work involves design engineering of machines, appliances, electrical and mechanical equipment, in U. S. and Canadian companies employing 20 or more people. Copies are sent on the basis of one for each group of four or five readers. Consulting and industrial engineering firms, research institutions and U. S. government installations, performing design engineering of products are also eligible.

Subscription in United States, possessions, and Canada for home-addressed copies and copies not qualified under above rules: One year, $10. Single copies $1.00. Other countries: One year, $25. When requesting changes of address, etc., please allow four to six weeks for processing.

Published every other Thursday and copyrighted 1959 by The Penton Publishing Co., Penton Bldg., Cleveland 13, Ohio. Accepted as Controlled Circulation publication at Cleveland, Ohio.

Hundreds of good reasons why Clark "PM" Relays are worth waiting for

The word is out about the most complete, integrated line of control relays available today.

If your shipment of Clark "PM" Relays has been delayed, please be patient. There's a very good reason. Seems like *everybody* wants them.

It all began when Clark first announced the completion of a *full line* of "PM" Relays. We were literally snowed under by an avalanche of orders.

We're happy to report, however, that our manufacturing facilities have been expanded to meet the demand and we're rapidly catching up—even though the avalanche continues.

Is it any wonder when you consider the many advantages the Clark "PM" Relay line offers: modular construction that makes possible integrated uniformity, compactness and flexibility . . . neater, more uniform panels . . . the greatest possible use of every square inch of valuable space.

Is it any wonder also, when you consider that *every* relay in the Clark "PM" line is manufactured with the same careful attention to detail that has long made Clark *"the standard of quality"* for industrial control.

No time-saving production short cuts are worth sacrificing this quality, even in the face of the tremendous demand created by customer preference. In fact, we're sure our customers wouldn't have it any other way.

Your Clark Controller sales representative or distributor will be glad to give you more reasons why Clark "PM" relays are your best control relay buy—well worth waiting for. Contact him or write direct to Clark Controller. PR3

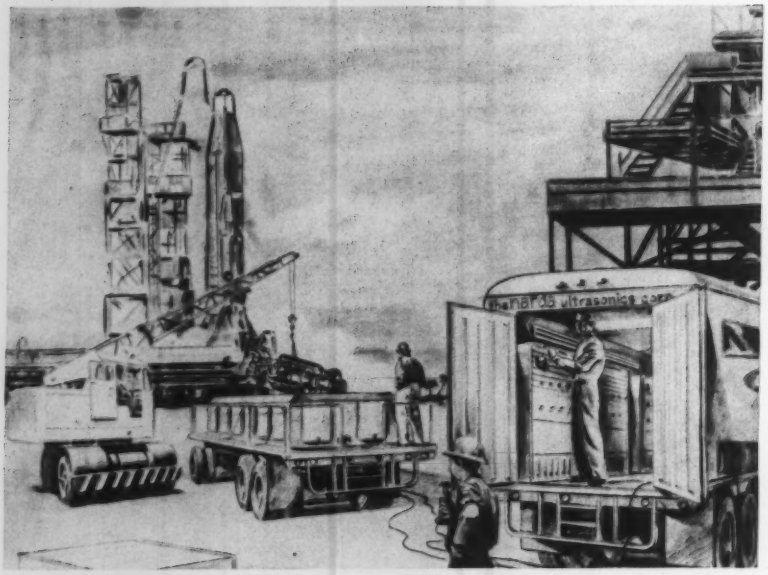
The CLARK CONTROLLER Company

Everything Under Control • 1146 E. 152nd St. • Cleveland 10, Ohio

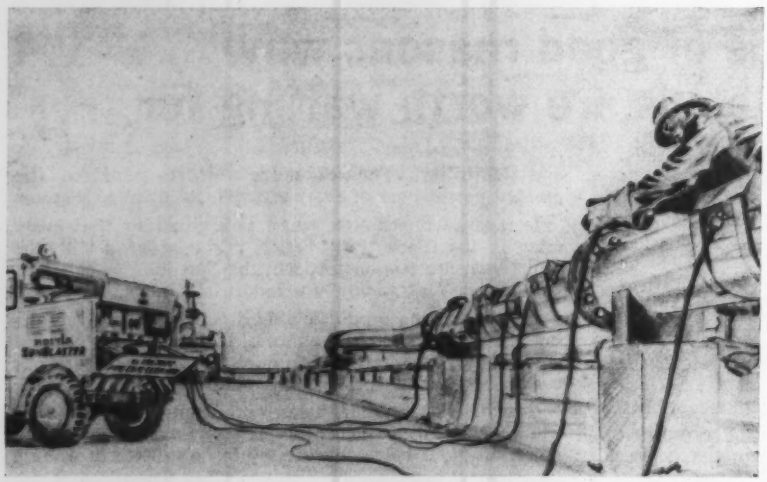
IN CANADA: CANADIAN CONTROLLERS, LIMITED • MAIN OFFICES AND PLANT, TORONTO

Circle 406 on Page 19

Missile Whistle Keeps 'Em Clean



Ultrasonic cleaning equipment, designed for on-site use, will help keep the nation's missile muscles ready. The self-propelled 24-ft cleaning tank, above, is agitated by a 30-kw frequency generator. It's designed to clean solid and liquid-fuel engines in one bath and will also handle a variety of other missile subassemblies.



Pipe cleaner uses "silent sound" to prevent sediment build-up in liquid-fuel supply lines. The system consists of a portable ultrasonic generator and a series of quick-coupling transducers which attach to the line. High-frequency sound waves transmitted to the pipe prevent foreign matter from adhering to inside walls. Both of the above systems are developments of Narda Ultrasonics Corp., Westbury, L. I., N. Y.

Controlled H-Bomb Reaction May Have Been Produced

Physicist Cautious; Wants Further Checks

WASHINGTON—A controlled thermonuclear reaction—first step toward harnessing the power of the hydrogen bomb—may have been accomplished at the Naval Research Laboratory. Before making any claims that may later have to be withdrawn, Dr. Alan C. Kolb, director of the project, wants additional experimental data. In any case, preliminary experiments are encouraging, and analysis does indicate that temperatures as high as 15 million F are produced.

In the experiments, a glass tube approximately 1¼ in. diam by 12 in. long is surrounded by a powerful magnetic field. Compressed preheated deuterium (heavy hydrogen) contained in the tube is excited by an electrical discharge, and breaks down into deuterium ions and electrons. Next, a 30-billion-watt pulse of electrical energy heats the ionized gas to about 3 million F, and forces it away from the tube's sides, confining it within a "tight" magnetic field. The magnetic field further constricts the gas, compressing and heating it. Finally the deuterons (deuterium ions) acquire so much energy that when they collide they fuse. Reaction time from discharge to fusion is about 10 micro-sec.

As a product of the reaction, neutrons are emitted. Proof of the fusion depends on careful analysis of these neutrons. Previously, "false" neutrons generated by other-than-fusion reactions have led scientists to claim production of controlled fusion, and have later forced them to retract their claims.

In Dr. Kolb's experiments, the deuterons produced move in random motion—a good sign. Deuterons produced in unsuccessful experiments have traveled in the same general direction, to ultimately produce false neutrons.

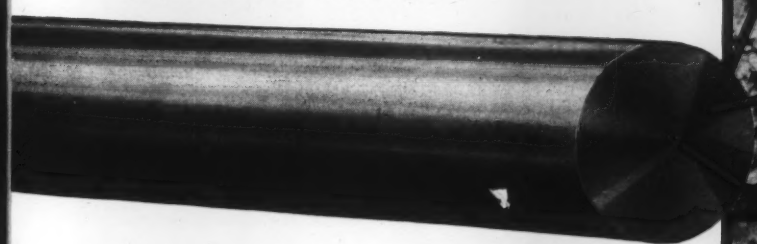
La Salle fatigue-proof STEEL BARS

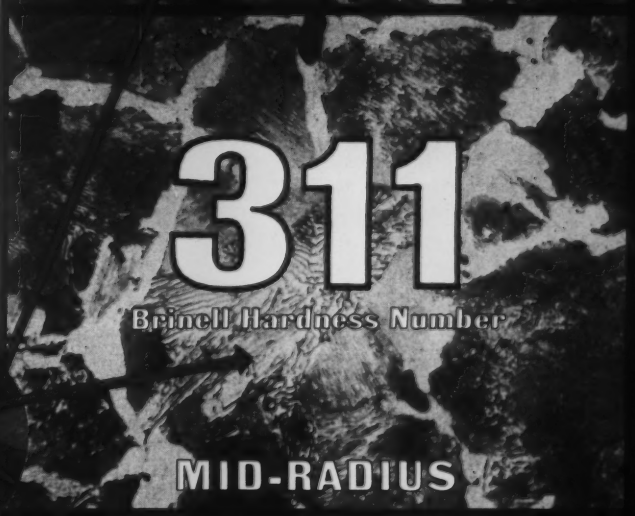
MADE BY e.t.d. PROCESS
Elevated Temperature Drawing

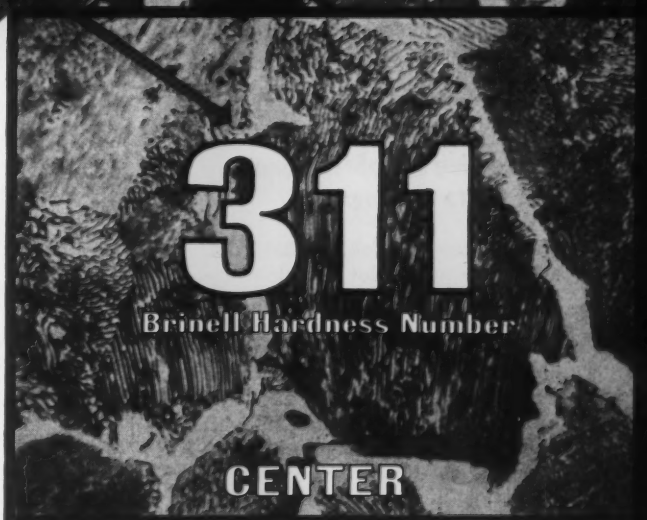
HAVE A UNIQUE COMBINATION OF

uniform properties

HIGH STRENGTH, MACHINABILITY, RESISTANCE TO WEAR AND FATIGUE, DIMENSIONAL STABILITY







The microscope shows the uniformity of FATIGUE-PROOF. Its uniformly pearlitic structure parallels its uniformity of properties from the surface to the center of the bar.

FATIGUE-PROOF strength and hardness are developed by "e.t.d." (Elevated Temperature Drawing). Unlike quenching and tempering, its effect is the same from surface to the center of the bar. It works a large bar as uniformly as it does a small bar.

There is no mass effect.

The microscope proves it. Surface, center, or mid-radius, FATIGUE-PROOF is pearlitic. There are no mixtures of bainite, martensite, and pearlite. FATIGUE-PROOF is uniform bar to bar, size to size, and lot to lot.

T. M.—Trade-marks of La Salle Steel Company

1⅛" round FATIGUE-PROOF. Magnification: 750X

JUST PUBLISHED—Request your copy of 24-page brochure, "A new material" . . . it tells the complete story of FATIGUE-PROOF.

Name_____

Company_____

Address_____

City_____ Zone____ State_____

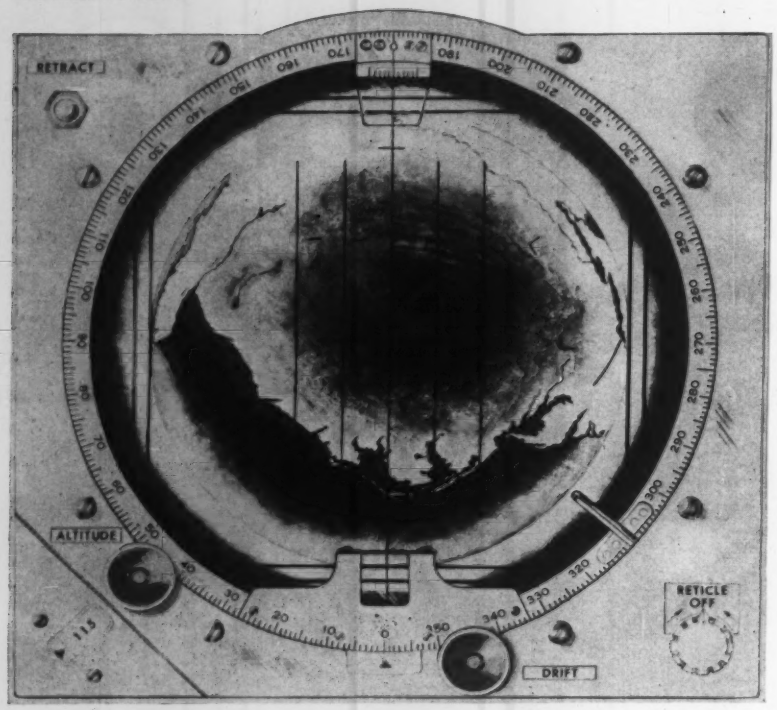
Mail to La Salle Steel Co., 1426 150th St., Hammond, Ind.

La Salle STEEL CO.

1426 150th Street • Hammond, Indiana

Manufacturers of America's Most Complete Line of Quality Cold-Finished Steel Bars

Circle 407 on Page 19



Satellite Spyglass

In the NASA Mercury space capsule, a low-power magnification, 190 degree view of earth may appear like this. Eastern seaboard of U.S. is seen from Florida (left) to Connecticut (right) with Mississippi River at top. Instruments will enable Astronaut to determine altitude, direction, and position in space. System is also equipped with a high-power magnification which superimposes a 20 degree field of view of 5 in. diam upon the larger 8 in. diam, 190-degree view. Mercury periscope-optical display system, developed by Perkin-Elmer Corp., Norwalk, Conn., serves both viewing and navigational functions.

Engineering's Highest Honor Will Go to Nonengineer

NEW YORK—The John Fritz Medal, awarded annually for notable scientific or industrial achievement, will be presented this December to Gwilym A. Price, lawyer, banker, industrialist, and presently chairman of the board of Westinghouse Electric Corp. The first man with a nonengineering background to receive the award, Mr. Price was selected for "his inspirational leadership, industrial pioneering and personal initiative in marshalling the creative forces of research and engineering to the cause of developing atomic power for the national defense and for the human welfare."

Mr. Price is cited as a leader in a new technical field: He formed an atomic power organization within his company which developed powerplants for the *U. S. S. Nautilis* and other ships in the Navy's nuclear-powered fleet. His engineers and scientists also designed the nation's first full-scale atomic-electric generating station at Shippingport, Pa.

The John Fritz Medal Board of Award consists of representatives from American Society of Mechanical Engineers, American Institute of Electrical Engineers, American Institute of Mining, Metallurgical and Petroleum Engineers, and American Society of Civil Engineers.

Past recipients of the award include John Fritz, pioneer in the iron and steel industry, who received the first award in 1902; Lord Kelvin; George Westinghouse; Alexander Graham Bell; Thomas Edison; and Orville Wright.

Topics

Racket in a rocket of the solid-propellant variety may permit control of the fuel's rate of burning and therefore the thrust produced. Acoustica Associates Inc., which is studying the method for NASA, estimates that suitable mixing of combustion gases by means of high-intensity sound waves could increase the burning rate three to ten times. Sound source would add only a few pounds to rocket's load.

• • •

Plastic goes to sea in a double-hulled tanker under construction in the USSR. Body and superstructure of the 100-ton, 100-ft long ship are of glass-fiber reinforced plastic, and only the base for the power plant and transmission components will be made of steel. Foam plastic fills the space between the two hull sections, and all parts are bonded by synthetic adhesive.

• • •

Cows with personal magnetism live longer. Apparently grazing cattle do not watch their diet and often chomp up staples, nails, and bits of wire. To counteract this careless over-indulgence, dairymen are force-feeding small cylindrical Alnico magnets to the cows. The magnets lodge in the bovine breadbasket, keeping metallic material from entering and damaging vital organs.

• • •

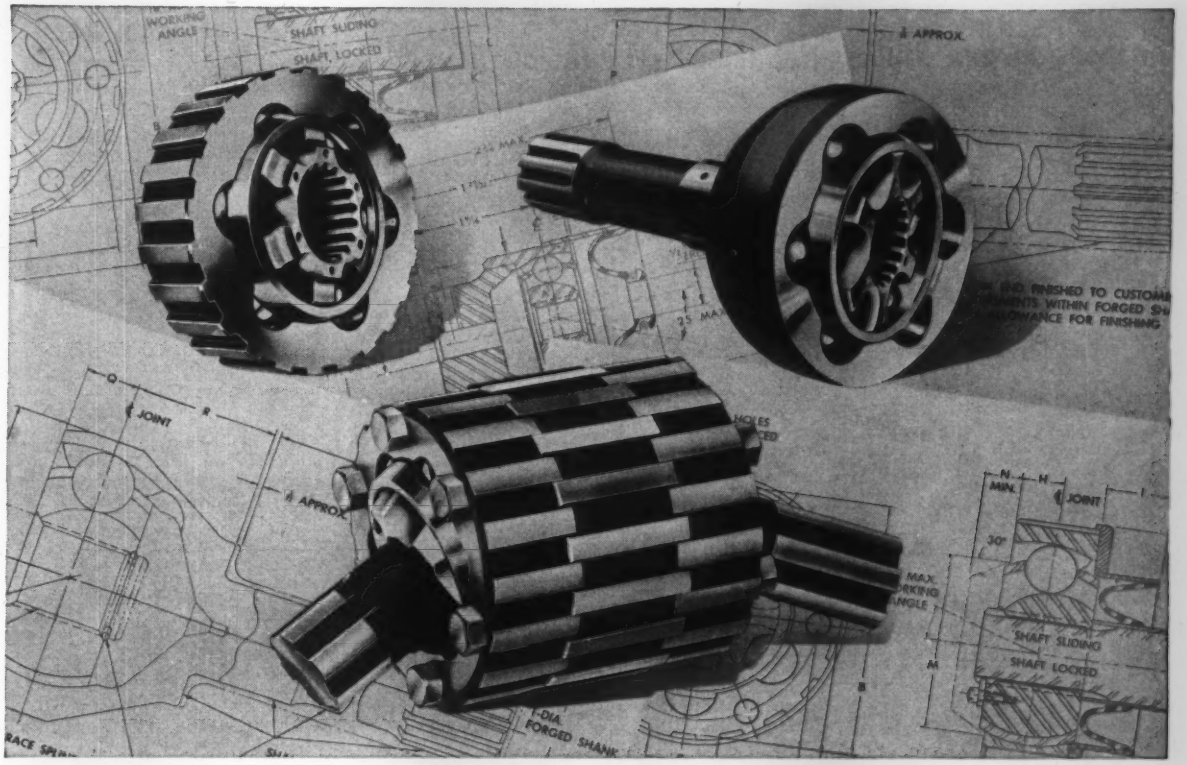
Two nonthirsty natives of France recently took top honors in a gasoline economy run in Newport News, Va. Stock-model Dauphines went 107.9 and 99.6 miles on one gallon in a five-hour competition with various other foreign and American cars.

• • •

Making plastic housewares less attractive—to dust—has been accomplished by Union Carbide Plastics Co., Div. of Union Carbide Corp. Injection molding of polyethylene compounds has always left the articles with an electrical charge which attracts dust particles. Two newly developed materials, Bakelite DNDA-0401 and DPD-7366, do not retain this charge, and therefore have built-in dust resistance.

• • •

Fighting fog with mist is a method proposed by a Londoner to rid the atmosphere of the soupy substance. Most fogs consist of tiny droplets, often formed around smoke particles, and almost always having a negative electric charge. Spraying the fog with a chemical solution, tailored to the particular type of fog, will give the drops an opposite charge and cause coalescence. The result is drizzle or rain, which some folks prefer to fog.



RZEPPA UNIVERSAL JOINTS Now A Product Of DANA

New Con-Vel Division To Produce Famed Constant Velocity Universal Joints—With These Advantages To You:

- **INCREASED SPEEDS**
- **REDUCED DOWN TIME**
- **LOWER MAINTENANCE COSTS**
- **HIGHER CAPACITY**

Rzeppa universal joints provide perfectly smooth torque all the time, every time, even at angles up to 35°! Rzeppa rules out bounce, chatter, vibration by keeping the hardened steel driving ball bearings in the correct bisecting plane, no matter what the shaft angle may be. The smoother, constant velocity performance of Rzeppa joints naturally increases shaft and bearing life; adds to over-all efficiency and economy of operation.

Rzeppa universal joints are available in a wide variety of sizes, angles, speeds and styles . . . designed for front drives, articulating axles, propeller shafts, and scores of special applications. For information on their many advantages write to—

DANA Con-vel

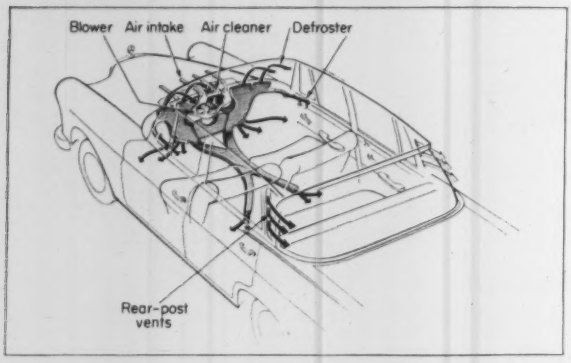
CON-VEL DIVISION

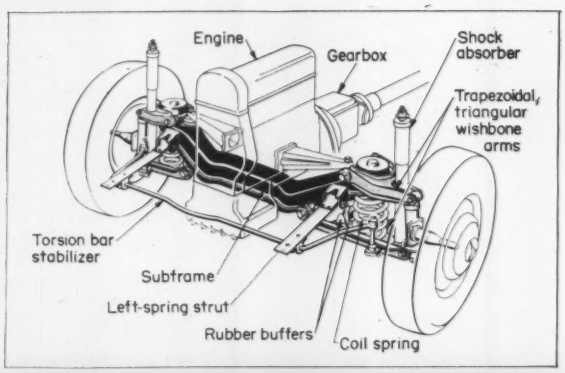
DANA CORPORATION

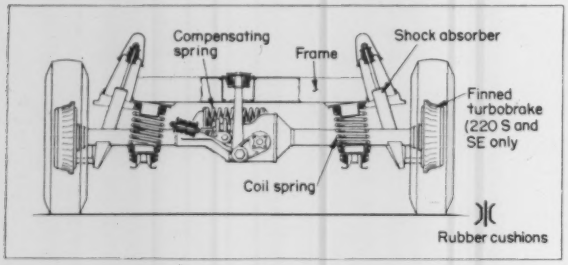
3901 CHRISTOPHER, DETROIT 11, MICHIGAN

Circle 408 on Page 19

Suspension and Styling Refinements Mark '60 Mercedes







STUTTGART, GERMANY — More chrome, and what may be the beginning of fins, give Mercedes' 220 models a conservative new look for 1960. The slight addition in chrome is incorporated in twin front bumpers. The fins, known officially as "guide ridges," are barely noticeable and have a purpose—to make parking easier. Further alterations in the distinguished car's appearance include unique combination headlights which put driving lights, parking lights, fog lights, and directional signals in a single integral unit. Wrap-around windshield and rear window are also new and add 35 per cent to the previous glass area. Vents in rear window posts—for pressure release—are the key to a revamped ventilation system.

The famous Mercedes suspension is carried forward in '60, with two minor changes on 220 models:

- Front shock absorbers have been moved outward, from within the coil springs, to improve damping of wheel oscillations. Rubber buffers supplement the design change.
- Transverse compensating spring, adapted from the 300 SL roadster, supplements the single-joint, low-pivot swing axle to give the 220 even better roadability and comfort.

Engines in the series have been slightly reworked to give higher compression (8.7 to 1) and 5 more horsepower.

Latest Navigational Aid Pictures the Earth Below

Indicates Aircraft Roll, Pitch, Yaw, Altitude, and Direction

CLIFTON, N. J.—Latest electronic system to solve bad-weather and night-flying problems for the airplane pilot is a ground-plane generator. With its assistance, the pilot will know his plane's exact relationship to the earth's surface, even under the most adverse flying conditions.

The system developed by Allen B. Dumont Laboratories Inc., presents the picture that the pilot would see if he could see the ground. Superimposed on the "ground" are a set of co-ordinate grid lines, e.g., running east-west and north-south, that indicate uniform spacing on the earth. The pattern formed when the aircraft is heading along one set of lines is made up of a horizon, a set of radial lines, and a set of parallel lines (at right angles to the center radial line). The vanishing point of the radial lines is the point at which the aircraft is headed.

As the aircraft noses down, the horizon and the rest of the pattern moves upward on the display. As the left wing drops, the right side of the pattern moves up, and the left side moves down. As the airplane gains altitude, the pattern becomes smaller. As the plane changes direction, the radial lines converge at a different point.

The exact position of the two sets of lines on the display device can be mathematically described by two equations. The equations include functions of the six degrees of freedom of the aircraft—roll, pitch, yaw, altitude, and translation in two directions relative to the earth. The equipment contains the necessary high-speed computers to solve the equations and form the picture for the pilot without flicker being observed on the screen.

Photo courtesy of National Screw & Mfg. Co.

COLD HEADING . . . every bolt a check on Aristoloy uniform quality

Bolts by the thousand or by the million . . . profitable cold heading requires steel of uniform structure and chemistry. Steel that can be formed to close, consistent dimensions and better surface finish . . . steel of good hardenability and heat treating characteristics.

Aristoloy electric furnace steels will meet your cold heading stock requirements . . . are ideally suited for most cold headed products.

For complete information about Aristoloy steels, carbon, alloy, stainless or leaded, call the Copperweld representative in your nearest large city . . . or write for NEW PRODUCTS and FACILITIES CATALOG.

ARISTOLOY STEELS

COPPERWELD STEEL COMPANY

ARISTOLOY STEEL DIVISION • 4017 Mahoning Ave., Warren, Ohio • EXPORT: Copperweld Steel International Co., 225 Broadway, New York 7, N. Y.

Steel Castings . . .

grounded since the start of the missile race, are finally beginning to soar. The reason: New developments in metal casting that give steel a tensile strength of almost . . .

300,000 psi

THE VIRTUES of steel castings as key structural components have often been admired by airframe designers. Complicated shapes that are exceedingly difficult to produce as forgings, machinings, weldments (or roundabout combinations of these), could be cast with big savings in cost, time, and manpower. But castings that qualify, particularly in strength, have not been available.

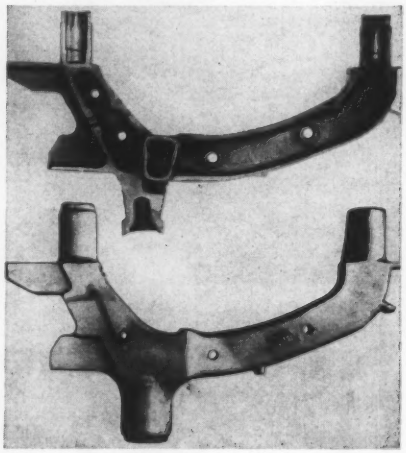
Armed with nothing but the demand, metallurgists at American Brake Shoe Co.'s Research Center, Mahwah, N. J., tackled the problem two years ago. The result: Production steel castings with tensile strengths ranging to 285,000 psi; laboratory castings to 300,000 psi. No secret ingredients are involved, only "meticulous control over the entire casting process."

The metallurgists' work is no longer locked up in the lab—high-strength castings are already in production. And current output is going to missile and aircraft builders.

These are properties for cast steel!

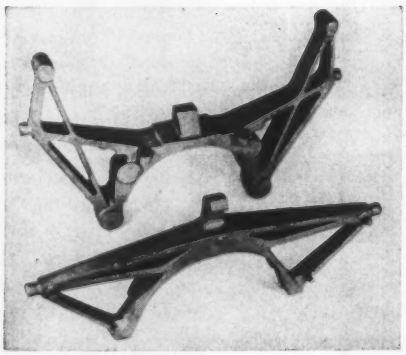
Alloy	Tensile Strength (psi)	Yield Strength (psi)	Elongation (per cent)
8740	285,000	230,000	4.5
4340	280,000	215,000	6.0
4330	250,000	200,000	9.0
H-11	260,000	205,000	9.5
17-4 PH	195,000	165,000	11.0

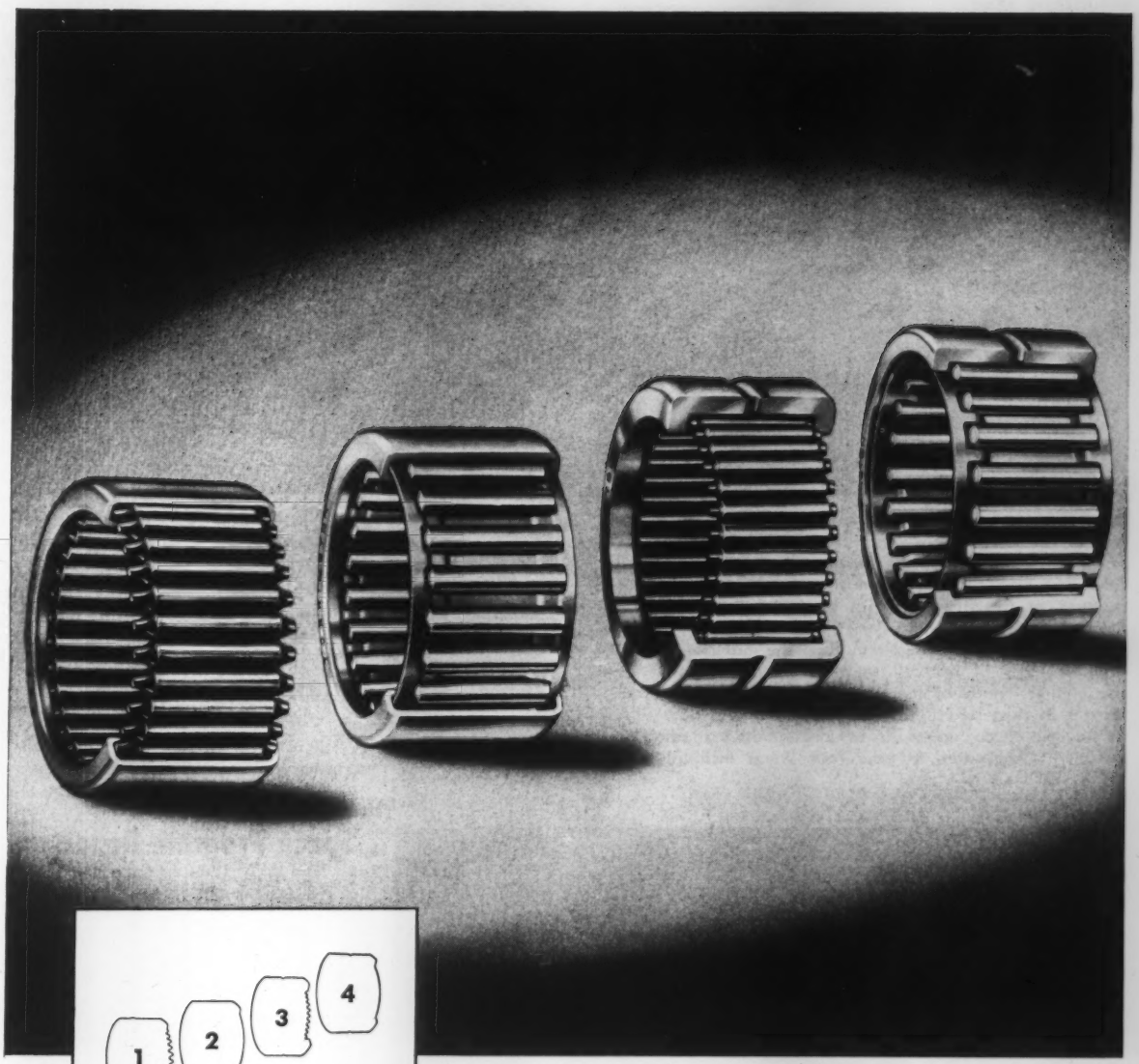
Wing mounting for weapon on a supersonic aircraft is being cast from 4330 steel. Cored construction of the part cuts weight to a minimum, and it meets a design requirement of 180,000 psi tensile strength.

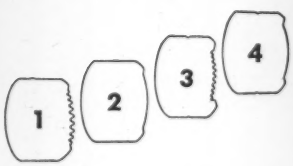


Airframe ring for a still classified missile, is cast from 8740 steel. It meets these rigid requirements: 260,000 psi ultimate tensile strength, 210,000 psi yield strength, and 3 per cent elongation.

Launching gear, now cast in production quantities, is made from 4330 steel. The part tests at 150,000 psi ultimate tensile strength, 120,000 psi yield strength, and 10 per cent elongation.







Torrington Drawn Cup Needle Bearing . . . for maximum radial capacity in minimum cross section . . . positioned by press fit—snap rings or shoulders unnecessary . . . runs directly on hardened shaft . . . most compact, light weight, economical.

Torrington Drawn Cup Roller Bearing . . . for higher speeds or long pregreased life . . . thin section race for simple press fit . . . runs directly on hardened shafts . . . unit construction for easy assembly . . . shaft-riding retainer.

Torrington Heavy Duty Needle Bearing . . . for use with thin section or split housing where extreme impact loads require heavy outer race . . . maximum shock resistance . . . full roller complement . . . unit construction.

Torrington Heavy Duty Roller Bearing . . . for combination of high speed, long pregreased life or shock resistance . . . roller stability provided by end-guiding . . . flange-riding retainer . . . unit design.

All of these types of bearings are available with inner races.

Only Torrington Makes All Four!

Torrington developed the Needle Bearing and its specialized variations. This breadth of experience assures impartial engineering recommendations based on specific application requirements. You can rely on Torrington to recommend the most compact and economical design compatible with operating conditions and performance requirements. Call on your Torrington representative for help in applying the right bearing in the right place. **The Torrington Company, Torrington, Conn.—and South Bend 21, Indiana.**

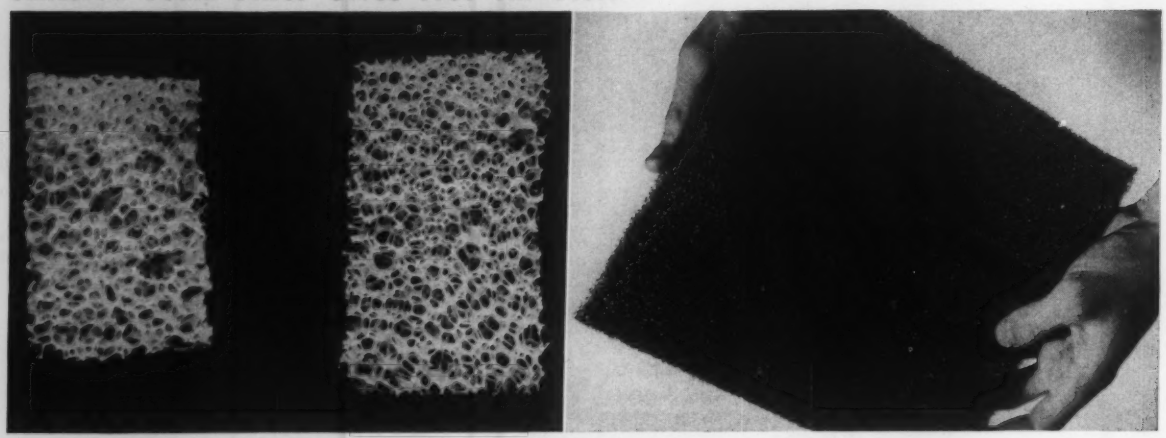
TORRINGTON BEARINGS

Every Basic Type of Anti-friction Bearing

NEEDLE • SPHERICAL ROLLER • TAPERED ROLLER • CYLINDRICAL ROLLER • NEEDLE ROLLERS • BALL • THRUST

Circle 410 on Page 19

Skeleton Foam Filter Gives Free Air Flow



Open-mesh structure of a new type of urethane foam is free of blocking membranes that give standard foam (left) uncertain filtering characteristics. Low resistance to air flow and high capacity for dust retention are outstanding features of the filter material made by Scott Paper Co., Chester, Pa. Although 97 per cent of its bulk is void, there are no direct channels through the material; strength and resiliency of the cell structure prevent channeling in use. Filters made of the foam can trap up to twice their weight in dust before seriously impeding the flow of air. In the table, giving results of a cumulative loading test, porosity is measured in pores per linear inch (pli); dust capacity was measured when resistance to air flow of 800 cfm reached 0.5 in. of water. Filtering characteristics are:

Thickness (in.)	Porosity (pli)	Resistance (in., H_2O)	Arresting Efficiency (per cent)	Dust Capacity (grams)
1	10	0.08	63.8	364
¾	30	0.18	75.0	90
½	20	0.07	62.3	168
½	30	0.12	69.6	118

Hybrid VTOL Goes into Production

Part helicopter and part autogyro, the Umbaugh 18 is one "suburban" aircraft that seems likely to succeed—it will be produced in quantity by a major aircraft builder. The unique craft takes off like a helicopter—rotor is clutched into the motor until it spins, with blades flat, at 300 rpm. Blade pitch is then changed to bite the air, and this automatically disengages the clutch. By this time, the craft has literally jumped about 15 ft straight up, and forward speed from the pusher propeller is adequate to maintain a steep climb (1050 fpm). Powered by a 180-hp Lycoming engine, the two-place VTOL cruises at 100 mph, has a service ceiling of 15,000 ft, and lands at from 0 to 10 mph in any space large enough to accommodate its 33-ft rotor. Designed by Umbaugh Aircraft Corp., Ocala, Florida, the craft will be produced by Fairchild Engine & Airplane Corp.

Space Program Report:

Glennan Reviews Past, Outlines Near Future

Los Angeles—Commenting on the first year of NASA operation to delegates attending the Fourth Symposium on Missiles and Space Technology, Dr. T. Keith Glennan, NASA's administrator, reviewed the civilian space program and pointed out paths it will follow. While divorcing it from the military program, he did acknowledge the two probably had a lot in common. Here are the points he made.

Where Do We Stand?

There seems to be a contest going on in this country in which many people are attempting to outdo each other in predicting exotic space accomplishments within the next few years. There is need for more common sense and good technical judgment to be injected into this picture.

We are not nearly as far advanced in space technology as we would like

to think. Our experiences in the space-vehicle field have been less than completely satisfactory. The ratio of successful launches to "successful failures" has not improved much in the past year. In all phases of propulsion and guidance there is much to be learned and applied before we undertake the difficult missions we all talk about so glibly.

We cannot and should not attempt all of the hundreds of projects that are being recommended. We will make faster progress if we move at a slower rate. Then we may learn and understand a bit more about what we have already done and about the information we have already acquired.

The question that plagues all of us is one of reliability. With distressingly few exceptions, we have not achieved complete success in any mission to date—success in the sense that the payload has been injected into orbit or into a deep-space trajectory within reasonable limits of the planned flight objectives.

What About the Future?

Already we have had to face up to the fact that we simply cannot do everything that is proposed. Some of the firing schedules developed nine months ago lacked the realism now characteristic in our planning. Thus far we have been engaged in completing experiments planned for the IGY. Within the next year, however, I think you will be able to note a new orderliness about the attack our people will be making.

We plan to concentrate initial efforts in deep space on lunar missions—near miss, orbiting, and hard and soft landings. This will develop the techniques necessary to accomplish missions into deeper space.

We expect to increase support for basic research and advanced technological efforts in the universities, in other nonprofit institutions, and in industry. Through these actions we hope to improve reliability of guidance, control, telemetry, auxiliary power units and sensors of all types, and of systems that employ these components.

We have used up much of our missile technology. We have drawn heavily on our capital—the knowledge and experience accumulated by NACA and the military over the past ten years. We must replenish that capital with new knowledge.

Hub assembly with integral preloaded duplex ball bearing, used in electronic missile system developed by Westinghouse Air Arm.

"IN-BORN" BEARING IN HUB ASSEMBLY

Gives Better Accuracy, Weight and Cost

Important advantages can often be gained by "designing in" bearings as a part of the unit in which they operate. A case in point is this hub assembly, produced and bearing-engineered by ITI.

Here, the two outer raceways and one inner raceway are formed in the hub and shaft; and the second inner ring — made separate to permit assembly — is close to a zero-tolerance fit. Compared to the usual design (using separate bearings), this construction gives (1) higher and more uniform accuracy, through elimination of 6 radial tolerances; (2) less weight and greater compactness, by eliminating 3 rings; and (3) lower total cost.

Other features include low running torque, labyrinth seals, high vibration resistance, and a dished hub held within .001" of the mathematically-specified contour.

In comparable ways, you too can benefit through our ability to design and produce bearings having unusual compactness or configuration, heat resistance, corrosion resistance, ultra precision, or other special properties. Let's talk it over.

FREE BULLETIN AFB-2 tells about the factors involved in special bearing applications, describes our work in this field, and shows a wide variety of special bearings. Write for it!

INDUSTRIAL TECTONICS, Inc.

ITI

MANUFACTURERS OF PRECISION BALLS AND BEARINGS

3682 JACKSON RD., ANN ARBOR, MICH.

WESTERN DIVISION PLANT: COMPTON, CALIFORNIA

NEW running time meters register from 1/10 second to 99,999 hours

The new Cramer Type 632 running time meters, or time-totalizers, offer a simple, accurate means of recording elapsed time in many industrial or laboratory operations. They are applied to forecast the need for repair or servicing of equipment, to record total operating time or down time, and to supply time data for checking the operating performance of any circuit, machine, or electrically-powered system. Direct current and 400-cycle alternating current units, available in limited time ranges, fulfill the need for monitoring laboratory, military and experimental equipment where portability is often important.

TYPE 632

Also available with standard round dial

Operation

A Cramer constant-speed motor drives a precision drum-type counter when power is applied to the motor circuit. From the instant the motor circuit is closed, elapsed time is recorded on the counter, in the total ranges and unit counts shown in the table below. The high-torque and instant start-stop characteristics of the motor assure reliable accuracy at all counter speeds. Control circuits to the motor can be arranged to operate the counter during equipment running time, during idle time, or during any specified operational phase.

Features

TIME RANGES — 9,999.9 seconds to 99,999 hours (see Table).

MOTOR RATINGS — 115 or 220v ac, 60, 50, and 25 cycles. In limited time ranges, motors are available for 115v 400-cycle ac, or for specified voltages between 6 and 32v dc.

RESET — optionally available, in all time ranges.

DIALS — Chinese square (illustrated), or standard round.

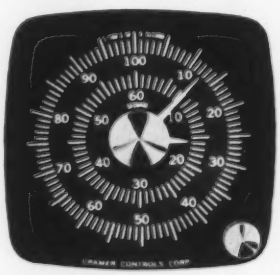
MIL-SPEC UNITS — available in hermetically sealed construction, to meet applicable specifications of MIL-E-5272A.

TYPE 632 TIME RANGES

COUNTS	TOTAL
1/10 sec.	9999.9 sec.
1 sec.	99999 sec.
1/100 min.	999.99 min.
1/10 min.	9999.9 min.
1 min.	99999 min.
1/10 hr.	9999.9 hr.
1 hr.	99999 hr.

and for 1/100-second accuracy, the Type 691 precision stop clock

In scientific research, and in many industrial and military applications requiring extremely precise time totalizing, Cramer Type 691 performs the same basic function as Type 632 but with still greater accuracy and flexibility. Total time ranges are either 60 minutes or 60 seconds. The inner scale on the dial reads directly in minutes or seconds. The outer scale reads either seconds or .01 minute for the 60-minute units, or .01 second for the 60-second unit. Reset is electrical, in 1/10 second, actuated either remotely or by a dial pushbutton. Motors, clutches and solenoids are available for all standard ac voltages and frequencies, and for 28 volts dc. One or two load switches (SPDT) are optionally available, for 5 amps at 115 and 230 volts ac or 2 amps at 28 volts dc. For load-switch operation, cams are precision cut to exact user specifications. Military units are available in hermetically sealed cases, to meet vibration, shock and other requirements of MIL-E-5272A.



TYPE 691

CRAMER CONTROLS
CORPORATION
Box 6, Centerbrook, Connecticut

Circle 412 on Page 19

Reader Information Service

SUBJECT INDEX

Editorial and Advertising content classified by subject and listed by page number for convenience when studying specific design problems. For further information on subjects advertised, refer to advertisement and circle Item Number on a Yellow Card—following page.

Abrasives, Adv. 108
Actuators, Adv. 110
Adhesvies, Edit. 44; Adv. 95, 108, 210
Aluminum and alloys, Adv. 86
Atom smashers, Edit. 34
Axles, Adv. 67

Balls, Adv. 15, 239
Barrel finishing, Edit. 156
Bars, rods, and rolls, Adv. 7, 41, 67, 108
Bearing materials, Edit. 199, 209; Adv. inside front cover, 41, 89, 170, 175, 195, 202, 203, 214
Bearings,
  ball, Adv. 13, 15, 21, 90, 102, 175, 233, 239
  miniature, Adv. 233
  needle, Adv. 13, 21, 164
  rod-end, Adv. 188, 231
  roller, Adv. 13, 21, 39, 90, 164, 213, 235, back cover
  sleeve Adv. 229
  thrust, Adv. 13, 21, 213
Bellows, Edit. 186
Belts,
  conveyor, Adv. 108
  transmission, Edit. 175, 195; Adv. 59, 63, 108
Beryllium and alloys, Adv. 86
Bimetals, Adv. 82
Blowers, Edit. 214; Adv. 223
Books, Edit. 223; Adv. 218, 238, 247
Brakes, Edit. 23, 189; Adv. 118, 239, 240
Brass (see Copper and alloys)
Bronze (see Copper and alloys)
Brushes, comutator, Adv. 195, 199
Bushings, Adv. 89, 202, 203, 214, 229

Cams, Edit. 140, 175, 230; Adv. 214
Capacitors, Edit. 170, 210
Carbon and graphite parts, Adv. 195, 199
Casters, Edit. 200
Castings,
  die, Adv. 55, 120, 186, 206
  high alloy, Adv. 196, 230
  investment, Adv. 115, 196
  iron, Adv. 80, 91, 115
  light alloy, Adv. 75, 115, 230
  malleable iron, Adv. 80
  nonferrous, Adv. 230
  permanent mold, Adv. 91
  sand, Adv. 80
  shell-molded, Adv. 80
  steel, Edit. 12; Adv. 46, 80, 115, 196, 220
Chain,
  conveyor, Adv. 172
  transmission, Adv. 63, 172, 229
Clad metals, Adv. 82
Clamps, Edit. 232; Adv. 203
Classified ads, Adv. 48, 201, 226, 228, 244
Clutches, Edit. 149; Adv. 32, 118, 179, 185, 190, 210, 237, 239, 240
Coatings (see also Finishes), protective, Edit. 165; Adv. 95, 104, 234
Cold heading, Adv. 11
Computers, components, Edit. 189, 194
Connectors, electric, Edit. 210; Adv. 30, 193
Contactors, Adv. 183
Contacts, Edit. 131; Adv. 82, 195, 199
Control systems,
  electric, Adv. 29
  hydraulic, Edit. 122
  pneumatic, Edit. 122
Controls,
  electric, Edit. 200, 202, 205, 214; Adv. 5, 16, 29, 38, 94, 106, 183, 186, 210, 214, 215, 235, 236, 242, inside back cover
  hydraulic, Adv. 77, 85, 103, 248
  mechanical, Edit. 135, 149, 174, 204, 230, 232; Adv. 110
  pneumatic, Adv. 74, 77, 103, 107, 248
Copper and alloys, Adv. 86, 170, 171
Corrosion-resistant alloys, Adv. 101
Counters, Edit. 184; Adv. 16, 224, 231
Couplings,
  fluid flow, Adv. 117, 196, 200, 237, 239, 242
  shaft, Adv. 9, 32, 78, 114, 172, 187, 229
Cylinders,
  hydraulic, Adv. 77, 85, 103, 241, 244
  pneumatic, Adv. 77, 103, 107, 234, 241, 244

Dials, Edit. 199
Drafting equipment, Edit. 217; Adv. 167, 202, 206, 238, 241, 242
Drives, adjustable speed, Edit. 168; Adv. 93, 100, inside back cover

Electric equipment (see specific type)
Enclosure systems, Adv. 189
Engineering department (see Management or Drafting)
Extrusions, Adv. 61

Facilities, general, Adv. 62, 71, 170, 174, 176, 180, 194, 220
Fans Adv. 68, 111
Fasteners,
  bolts, studs, screws, Edit. 184; Adv. 1, 37, 60, 70, 96, 174, 203, 217, 243
  insert Edit. 198; Adv. 169, 181
  nuts, Adv. 44, 84, 197, 238
  pin, Edit. 194; Adv. 169, 211, 233
Filters, Adv. 27, 74, 83, 99, 116
Finishes, (see also Coatings), protective, Adv. 104
Fittings, pipe, tube, and hose, Adv. 1, 117, 196, 237, 239, 242
Flow indicators, Adv. 235
Forgings, Adv. 71, 86, 98, 170
Friction materials, Adv. 89, 108, 179, 199

Gages (see also Instruments), Adv. 235, 241
Gaskets, Adv. 61, 66, 108, 203
Gears, Edit. 149; Adv. 2, 47, 176, 192, 198, 210, 214, 229, 231, 238, 242
Generators, Edit. 170; Adv. 100, 119, 235, inside back cover

Handles, Edit. 192
Heat exchangers, Edit. 230
Heating, Edit. 44; Adv. 243
Heat-resistant alloys, Adv. 79, 101
Heaters, Adv. 208
Hose, nonmetallic, Edit. 132; Adv. 108
Hydraulic equipment (see specific type)
Hydraulic fluid, Adv. 56

Instruments, Adv. 173, 220, 222, 240
Insulators, Adv. 203

Lighting, Edit. 42; Adv. 30, 240
Lubricants, Adv. 56, 104
Lubrication,
  equipment, Adv. 1, 74, 99, 117, 214, 236
  systems, Adv. 1, 54, 236

Magnesium and alloys, Adv. 86, 234
Magnets, Adv. 168
Metals (see specific type)
Motors (electric),
  fractional and intergral hp, Edit. 198, 206; Adv. 35, 58, 68, 92, 100, 119, 205, 233, 236, inside back cover
  gearmotors, Adv. 180, 235, 236, inside back cover
  servomotors, Edit. 196

Packings, Adv. 2, 41, 61, 108, 227
Panel windows, Edit. 152
Patent infringement, Edit. 133
Pistons, Edit. 129
Planetary genevas, Edit. 135
Plastics, Edit. 192, 206; Adv. 41, 61, 108, 186, 203
  laminates, Adv. 191, 203
  molding, Adv. 45, 175, 177, 182, 186, 192, 203, 207
  reinforced, Adv. 192

MACHINE DESIGN is indexed in Industrial Arts and Engineering Index Service, both available in libraries, generally

Plugs, Edit. 210; Adv. 30, 193, 240
Pneumatic equipment (see specific type)
Porcelain enamels, Edit. 165
Potentiometers, Edit. 150, 202, 212; Adv. 29, 210
Powder metallurgy, Adv. inside front cover, 108, 112, 214
Power supplies, Edit. 220, 222; Adv. 235
Printed circuits, Edit. 170
Processing equipment, Edit. 130; Adv. 40, 41, 237
Pulleys (see also Sheaves), Adv. 200
Pumps,
  hydraulic, Edit. 195; Adv. 68, 105, 200, 209, 216
  pneumatic, Edit. 195, 212; Adv. 244

Reducers, speed, Edit. 184, 191; Adv. 190, 192, 198, 212, 229, 236
Regulators,
  flow, Edit. 130; Adv. 27, 74
  pressure, Adv. 74, 99, 240
Relays, Adv. 5, 94, 183, 186, 193, 214
Research and development, Edit. 174
Resistors, Edit. 170
Rubber, Adv. 59, 76, 174
  molding, Adv. 2, 61, 108, 174, 177

Sealants, Adv. 41, 95, 176
Seals, Edit. 132, 175, 186, 190, 205; Adv. 2, 41, 61, 66, 89, 117, 174, 195, 196, 199, 227
  mechanical, Adv. 61
Servomotors, Adv. 210
Shafts, Adv. 175
  flexible, Edit. 149; Adv. 73
Shapes, special, Adv. inside front cover, 112, 186, 214, 242
Shear spinning, Edit. 176
Sheaves (see also Pulleys), Adv. 200
Small parts, Adv. inside front cover, 112, 186, 194, 203, 214
Sockets, Adv. 240
Springs, Edit. 131, 146, 148, 173; Adv. 222, 243
Sprockets, Adv. 63, 198, 229
Starters, motor, Edit. 216; Adv. 242
Steel, Adv. 7, 11, 64, 72, 79, 86, 98, 112, 219, 243
  stainless, Adv. 112, 204
Switches, Edit. 200, 204, 214; Adv. 30, 38, 94, 106
Swivel joints, Adv. 237, 239

Tape, Edit. 220; Adv. 108, 203
Terminals, Edit. 210; Adv. 30, 193
Testing, Adv. 237, 241
Textured metals, Adv. 43
Timers, Adv. 16, 215
Tips and techniques, Edit. 160
Tires, Edit. 24
Titanium and alloys, Adv. 86, 234
Torque converters, Adv. 32, 234
Transformers, Edit. 170
Transistors, Edit. 31, 191
Transmissions, adjustable speed, Adv. 190, 229, 234
Tubing, Edit. 174, 192; Adv. 41, 49, 71, 108, 112, 203
Tubular columns, Edit. 161

Uncommon materials, Adv. 86
Universal joints, Adv. 9, 114

Valves,
  hydraulic, Edit. 184, 202, 209; Adv. 27, 42, 103, 232, 242, 248
  pneumatic, Edit. 184, 209; Adv. 42, 74, 103, 248
Vulcanized fiber, Adv. 191, 203

Washers, Adv. 202
Wheels, Edit. 147
Wire and wire products, Edit. 184; Adv. 53, 181

USE A YELLOW CARD
for More Information . . .

CIRCLE ITEM NUMBERS—Throughout the magazine, each advertisement carries an Item Number for use in requesting further information. All product descriptions, announcements and Helpful Literature items are also numbered, and for greater convenience are indexed below by Item Numbers.

EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

Index to New Parts & Helpful Literature

BY ITEM NUMBERS

HELPFUL LITERATURE— descriptions start on page 178

	ITEM NUMBER
Hydraulic Pumps	631
The International Inch	632
Quick-Release Fastener	633
Spot Weld Fasteners	634
Damper Regulator	635
Air & Hydraulic Valves	636
Temperature Regulator	637
Centrifugal Castings	638
Packings	639
Counters	640
Snap-Action Switches	641
Drafting Supplies	642
Variable Transformers	643
Semiconductors	644
Variable Speed Drives	645
Dacron V-Belts	646
Machining of Aluminum	647
Heat Exchangers	648
Wire & Strip Forming	649
Miniature Toggle Switch	650
Motor Catalog Changes	651
Engines & Power Units	652
Textured Metals	653
Electric Tachometers	654
Epoxy Products	655
Drafting Templates	656
Nickel-Base Alloy	657
Printed Circuit Tapes	658
Engine Starting Controls	659
Floodlights	660
Valves	661
Linear Actuators	662
Servo Clamps	663
Metal Forming & Finishing	664
Fuse Equipment	665
Semitubular Rivets	666
Preamplifiers	667
Clutch-Pulley Package	668
Transmissions & Reducers	669
Magnesium Castings	670
Ingot Iron Tubing	671
Nickel Casting Alloys	672
Cold Extruded Parts	673
Aluminum-Bronze Bars	674

NEW PARTS & ENGINEERING EQUIPMENT— descriptions start on page 184

	ITEM NUMBER
Subminiature Speed Reducers	675
Spring Wire	676
Miniature Counter	677
Palm-Button Valve	678
Triple-Purpose Screw	679
Bellows and Seals	680
Miniature Brakes	681
Readout Photocells	682
Rolling Diaphragm Seal	683
Speed Reducers	684
Germanium Tetrodes	685
Teflon Tubing	686
Revolving Handles	687
Precision Pins	688
Semiconductor Component	689
Rotary Pump	690
V-Belt Drives	691
Inertia-Damped Servomotor	692
Blind Fastener	693
AC Motors	694
Bearing Material	695
Engraved Dials	696
Aluminum Casters	697
Limit Switch	698
Trimming Potentiometer	699
Solenoid Valve	700
Pressure Switch	701
Recycling Controller	702
Reusable Seal	703
Epoxy Compound	704
Electric Motor	705
Tension Bushes	706
Solenoid Valve	707
Ceramic Capacitor	708
Electrical Plugs	709
Piston Air Pump	710
Panel-Mount Potentiometers	711
Toggle Switch	712
Vane-Axial Blower	713
Magnetic Starter	714
Metric Circles Template	715
Photographic Papers	716
DC Power Supply	717
Magnetic Tape	718

MACHINE DESIGN
SEPT. 3, 1959

Circle item number for information on products advertised or described or copies of literature.

401	431	461	491	521	551	581	611	641	671	701	731	761	791	821	851
402	432	462	492	522	552	582	612	642	672	702	732	762	792	822	852
403	433	463	493	523	553	583	613	643	673	703	733	763	793	823	853
404	434	464	494	524	554	584	614	644	674	704	734	764	794	824	854
405	435	465	495	525	555	585	615	645	675	705	735	765	795	825	855
406	436	466	496	526	556	586	616	646	676	706	736	766	796	826	856
407	437	467	497	527	557	587	617	647	677	707	737	767	797	827	857
408	438	468	498	528	558	588	618	648	678	708	738	768	798	828	858
409	439	469	499	529	559	589	619	649	679	709	739	769	799	829	859
410	440	470	500	530	560	590	620	650	680	710	740	770	800	830	860
411	441	471	501	531	561	591	621	651	681	711	741	771	801	831	861
412	442	472	502	532	562	592	622	652	682	712	742	772	802	832	862
413	443	473	503	533	563	593	623	653	683	713	743	773	803	833	863
414	444	474	504	534	564	594	624	654	684	714	744	774	804	834	864
415	445	475	505	535	565	595	625	655	685	715	745	775	805	835	865
416	446	476	506	536	566	596	626	656	686	716	746	776	806	836	866
417	447	477	507	537	567	597	627	657	687	717	747	777	807	837	867
418	448	478	508	538	568	598	628	658	688	718	748	778	808	838	868
419	449	479	509	539	569	599	629	659	689	719	749	779	809	839	869
420	450	480	510	540	570	600	630	660	690	720	750	780	810	840	870
421	451	481	511	541	571	601	631	661	691	721	751	781	811	841	871
422	452	482	512	542	572	602	632	662	692	722	752	782	812	842	872
423	453	483	513	543	573	603	633	663	693	723	753	783	813	843	873
424	454	484	514	544	574	604	634	664	694	724	754	784	814	844	874
425	455	485	515	545	575	605	635	665	695	725	755	785	815	845	875
426	456	486	516	546	576	606	636	666	696	726	756	786	816	846	876
427	457	487	517	547	577	607	637	667	697	727	757	787	817	847	877
428	458	488	518	548	578	608	638	668	698	728	758	788	818	848	878
429	459	489	519	549	579	609	639	669	699	729	759	789	819	849	879
430	460	490	520	550	580	610	640	670	700	730	760	790	820	850	880

SEND COPIES OF FOLLOWING ARTICLES IN THIS ISSUE

Page No. — Title of Article

....

....

....

....

CARD INVALID WITHOUT COMPANY NAME — TYPE OR PRINT

NAME _____

TITLE _____

COMPANY _____

PRODUCT MANUFACTURED _____

ADDRESS _____

CITY _____ ZONE____

STATE _____

Do not use this card after Nov. 3, 1959

MACHINE DESIGN
SEPT. 3, 1959

Circle item number for information on products advertised or described or copies of literature.

401	431	461	491	521	551	581	611	641	671	701	731	761	791	821	851
402	432	462	492	522	552	582	612	642	672	702	732	762	792	822	852
403	433	463	493	523	553	583	613	643	673	703	733	763	793	823	853
404	434	464	494	524	554	584	614	644	674	704	734	764	794	824	854
405	435	465	495	525	555	585	615	645	675	705	735	765	795	825	855
406	436	466	496	526	556	586	616	646	676	706	736	766	796	826	856
407	437	467	497	527	557	587	617	647	677	707	737	767	797	827	857
408	438	468	498	528	558	588	618	648	678	708	738	768	798	828	858
409	439	469	499	529	559	589	619	649	679	709	739	769	799	829	859
410	440	470	500	530	560	590	620	650	680	710	740	770	800	830	860
411	441	471	501	531	561	591	621	651	681	711	741	771	801	831	861
412	442	472	502	532	562	592	622	652	682	712	742	772	802	832	862
413	443	473	503	533	563	593	623	653	683	713	743	773	803	833	863
414	444	474	504	534	564	594	624	654	684	714	744	774	804	834	864
415	445	475	505	535	565	595	625	655	685	715	745	775	805	835	865
416	446	476	506	536	566	596	626	656	686	716	746	776	806	836	866
417	447	477	507	537	567	597	627	657	687	717	747	777	807	837	867
418	448	478	508	538	568	598	628	658	688	718	748	778	808	838	868
419	449	479	509	539	569	599	629	659	689	719	749	779	809	839	869
420	450	480	510	540	570	600	630	660	690	720	750	780	810	840	870
421	451	481	511	541	571	601	631	661	691	721	751	781	811	841	871
422	452	482	512	542	572	602	632	662	692	722	752	782	812	842	872
423	453	483	513	543	573	603	633	663	693	723	753	783	813	843	873
424	454	484	514	544	574	604	634	664	694	724	754	784	814	844	874
425	455	485	515	545	575	605	635	665	695	725	755	785	815	845	875
426	456	486	516	546	576	606	636	666	696	726	756	786	816	846	876
427	457	487	517	547	577	607	637	667	697	727	757	787	817	847	877
428	458	488	518	548	578	608	638	668	698	728	758	788	818	848	878
429	459	489	519	549	579	609	639	669	699	729	759	789	819	849	879
430	460	490	520	550	580	610	640	670	700	730	760	790	820	850	880

SEND COPIES OF FOLLOWING ARTICLES IN THIS ISSUE

Page No. — Title of Article

....

....

....

....

CARD INVALID WITHOUT COMPANY NAME — TYPE OR PRINT

NAME _____

TITLE _____

COMPANY _____

PRODUCT MANUFACTURED _____

ADDRESS _____

CITY _____ ZONE____

STATE _____

Do not use this card after Nov. 3, 1959

MACHINE DESIGN
SEPT. 3, 1959

Circle item number for information on products advertised or described or copies of literature.

401	431	461	491	521	551	581	611	641	671	701	731	761	791	821	851
402	432	462	492	522	552	582	612	642	672	702	732	762	792	822	852
403	433	463	493	523	553	583	613	643	673	703	733	763	793	823	853
404	434	464	494	524	554	584	614	644	674	704	734	764	794	824	854
405	435	465	495	525	555	585	615	645	675	705	735	765	795	825	855
406	436	466	496	526	556	586	616	646	676	706	736	766	796	826	856
407	437	467	497	527	557	587	617	647	677	707	737	767	797	827	857
408	438	468	498	528	558	588	618	648	678	708	738	768	798	828	858
409	439	469	499	529	559	589	619	649	679	709	739	769	799	829	859
410	440	470	500	530	560	590	620	650	680	710	740	770	800	830	860
411	441	471	501	531	561	591	621	651	681	711	741	771	801	831	861
412	442	472	502	532	562	592	622	652	682	712	742	772	802	832	862
413	443	473	503	533	563	593	623	653	683	713	743	773	803	833	863
414	444	474	504	534	564	594	624	654	684	714	744	774	804	834	864
415	445	475	505	535	565	595	625	655	685	715	745	775	805	835	865
416	446	476	506	536	566	596	626	656	686	716	746	776	806	836	866
417	447	477	507	537	567	597	627	657	687	717	747	777	807	837	867
418	448	478	508	538	568	598	628	658	688	718	748	778	808	838	868
419	449	479	509	539	569	599	629	659	689	719	749	779	809	839	869
420	450	480	510	540	570	600	630	660	690	720	750	780	810	840	870
421	451	481	511	541	571	601	631	661	691	721	751	781	811	841	871
422	452	482	512	542	572	602	632	662	692	722	752	782	812	842	872
423	453	483	513	543	573	603	633	663	693	723	753	783	813	843	873
424	454	484	514	544	574	604	634	664	694	724	754	784	814	844	874
425	455	485	515	545	575	605	635	665	695	725	755	785	815	845	875
426	456	486	516	546	576	606	636	666	696	726	756	786	816	846	876
427	457	487	517	547	577	607	637	667	697	727	757	787	817	847	877
428	458	488	518	548	578	608	638	668	698	728	758	788	818	848	878
429	459	489	519	549	579	609	639	669	699	729	759	789	819	849	879
430	460	490	520	550	580	610	640	670	700	730	760	790	820	850	880

SEND COPIES OF FOLLOWING ARTICLES IN THIS ISSUE

Page No. — Title of Article

....

....

....

....

CARD INVALID WITHOUT COMPANY NAME — TYPE OR PRINT

NAME _____

TITLE _____

COMPANY _____

PRODUCT MANUFACTURED _____

ADDRESS _____

CITY _____ ZONE____

STATE _____

Do not use this card after Nov. 3, 1959

FIRST CLASS
Permit No. 36
CLEVELAND, OHIO

BUSINESS REPLY MAIL
No Postage Stamp Necessary if Mailed in the United States

—POSTAGE WILL BE PAID BY—

MACHINE DESIGN
Penton Building
Cleveland 13, Ohio

Reader's Service Dept.

FIRST CLASS
Permit No. 36
CLEVELAND, OHIO

BUSINESS REPLY MAIL
No Postage Stamp Necessary if Mailed in the United States

—POSTAGE WILL BE PAID BY—

MACHINE DESIGN
Penton Building
Cleveland 13, Ohio

Reader's Service Dept.

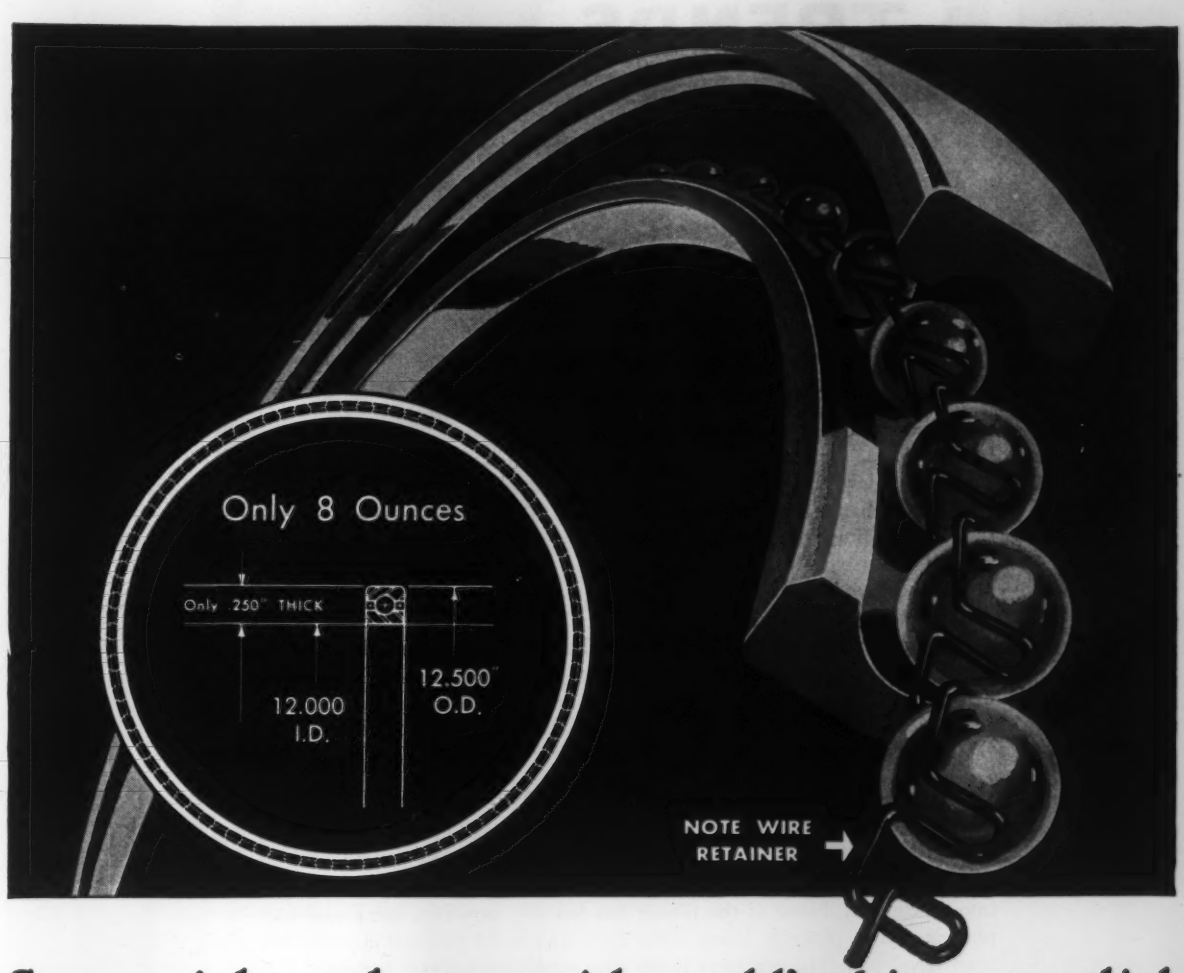
FIRST CLASS
Permit No. 36
CLEVELAND, OHIO

BUSINESS REPLY MAIL
No Postage Stamp Necessary if Mailed in the United States

—POSTAGE WILL BE PAID BY—

MACHINE DESIGN
Penton Building
Cleveland 13, Ohio

Reader's Service Dept.



Save weight and space with world's thinnest radial ball bearings—*Reali-Slim* by Kaydon

. . . now carried in stock in 4" to 12" bores

HERE it is! A *Reali-Slim* radial ball bearing with a wire separator that has just short of a full complement of balls for maximum capacity. What's more, you still get all the advantages of a separator between the balls. This design also gives you a bearing that's light-in-weight and is, without a question, the thinnest bearing ever built in this diameter.

Whatever your product design, there's a small or large diameter *Reali-Slim* bearing that can be the right answer to your thin-section bearing problems.

The radial ball bearing, illustrated here, is *really slim* — 12.000" I.D., 12.500" O.D., .250" thick . . . *and weighs only eight ounces.* It has 9,810 lbs. static load capacity, 1,256 lbs. at 100 rpm. Kaydon is able to produce *Reali-Slim*, high-precision bearings because Kaydon specializes in the unusual.

Kaydon bearing engineers are prepared to give you valuable help with technical, thin-section bearing problems.

For detailed information on Kaydon's *Reali-Slim* line, ask for engineering catalog No. 54-RS3 detailing:

Reali-Slim Ball Bearings — Conrad, angular contact and 4-point contact types in seven standard cross sections from ¼" to 1.000" and in bore diameters from 4" to 40".

Reali-Slim Roller Bearings — Radial and taper roller types in cross sections from 9/16" and in bore diameters from 5" to 40".

THE KAYDON ENGINEERING CORP.

MUSKEGON • MICHIGAN

K-561R

All types of ball and roller bearings — 4" bore to 178" outside diameter . . .

Taper Roller • Roller Thrust • Roller Radial • Needle Roller • Ball Radial • Ball Thrust Bearings

Circle 413 on Page 19

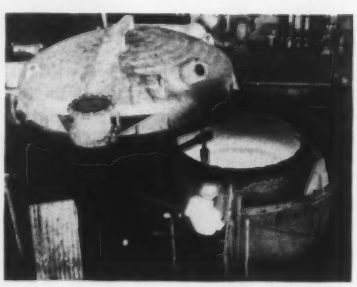
one control for earthmovers

A single lever controls steering, acceleration, and deceleration in heavy-duty vehicles using a new hydrostatic system developed by Dowty Hydraulic Units Ltd., Ashchurch, England. When the control lever is in central position, the engine idles, wheels are locked. Moving the lever from front to back puts the vehicle through the full range of motion from full forward to full reverse. The engine provides a positive flow of low-velocity, high-pressure oil which drives a hydraulic motor coupled to the wheels. The elimination of many conventional parts, including the mechanical drive line, allows greater flexibility in vehicle design. Brakes, except one for parking, are also eliminated.

plastics makers narrow lab-to-production gap

Traditional time-consuming safeguards to new-product marketing are being bypassed by fast-moving plastics manufacturers. Without benefit of customer sampling or pilot runs, Union Carbide Corp. is rushing its new Polymer X into production. None of the plastic has left the company, but a new million-pounds-a-year plant is being completed, and a 20-year sales projection has been developed. The company is working simultaneously on research, development, engineering, marketing, patents, and financing. Although this kind of speed-up would make product failure costly, UCC spokesmen explain that new methods of getting "progress information" can speed up decisions to increase, decrease, or stop the effort before it gets too far out of hand. Besides, they think the chance to outdraw a competitor makes the gamble worthwhile.

vacuum trick licks hydrogen embrittlement



Hydrogen-free steel will be available on an economical production basis using a vacuum technique that degasses molten steel in the ladle. Previous methods that used vacuum degassing during pouring were said to be uncertain and expensive. Pouring, for example, was limited to one mold. The new technique uses a vacuum chamber to degas a full ladle before pouring. After leaving the degassing chamber, the ladle is free to pour into several molds. Developer, A. Finkl & Sons Co., Chicago, uses helium, bubbled through the melt by a snorkel-like device, to scavenge additional hydrogen from the metal. Tests show 60 per cent removal of hydrogen.

liquid-cooled discs may solve truck-brake problems

Heat dissipation by radiation has reached a practical limit in the drum-type brakes on trucks and other heavy-duty vehicles. Temperatures in excess of 1000 F are common in truck drums, while the best organic brake linings fade fast at 700 F. Liquid-cooling has been tried, and plagued by cost and complexity. Liquid cooling applied to disc brakes, however, may provide a practical answer. Engineers at Wagner Electric Co., St. Louis, have been road testing a big highway rig equipped with liquid-cooled discs and report outstanding performance. They give much credit to the inherent structure and operation of discs: Mechanical deflection is reduced due to rugged construction of disc and housing; thermal expansion is perpendicular to plane of applied force; lining loading is uniform; unsprung weight is less than that of conventional air brakes by as much as 120 lb per axle.

Navy needs a slow airplane

Adoption of the Eagle—a new long-range, air-to-air missile—has forced Navy to look around for a subsonic aircraft to carry the weapon. "By emphasizing performance of the missile," says Vice Admiral J. T. Hayward, Deputy Chief of Naval Operations, "we hope to hold down costs and complexity of the airplane. Also, we are approaching the limits in aircraft that can operate from carriers." Navy is looking for a turboprop or turbofan-powered aircraft, which will sacrifice in performance for a big gain in range.

atomic energy volunteers for humdrum jobs

Reactors to produce moderate heat for direct use in industrial processes are being proposed to industry by AEC. A one-day symposium will be held in Germantown, Md., on Oct. 1, to show industry representatives the advantages of reactor heaters over conventional systems. Among the benefits cited: Elimination of smoke and waste-gas discharge to the atmosphere, reduced fuel-storage space, infrequent refueling periods, plant location independent of fuel sources, and production of valuable fission byproducts. Reactors can supply heat for production of primary metals, glass, cement, petroleum, paper, chemicals, coal products, and food. They may also be used in central-heating plants, and for salt-water conversion.

government researching corrosion mechanics

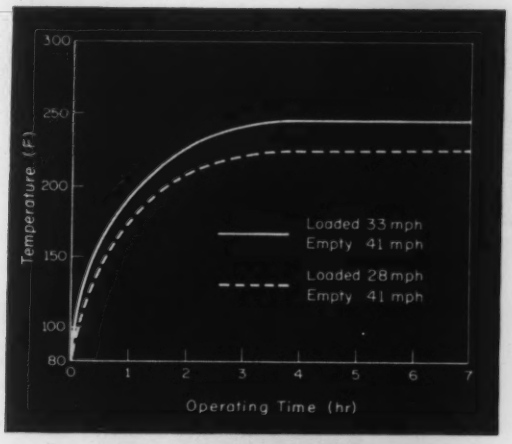
Providing science and industry with solutions to corrosion problems is the goal of National Bureau of Standards corrosion-process investigations. Large single metal crystals are being used to correlate corrosion with atom arrangement in the crystal lattice of metals. Electrical effects and cathodic protection are also under study, as is the nature and mechanism of oxide-film formation. By attacking the problem from many different directions, the Bureau hopes to improve present methods of combating corrosion.

Off-the-road tires are getting bigger, and they represent bigger problems for vehicle designers. Enough rubber for over 300 passenger-car tires goes into an off-the-road giant like this two-ton sample. Thirty-two plys will allow it to go 30 mph with a vehicle carrying a 30-ton load. Goodyear prices this tire at $14,000. Even more modest off-the-road tires represent a big investment, so they'd better hold up. That's why the . . .

HEAT'S ON BIG TIRES

TIRE DESIGN rests uncomfortably on three shifting points of emphasis —maximum life, maximum speed, and maximum traction. Roughly speaking, any two of these tire qualities can be improved at the expense of the third.

But mounting performance demands from off-the-highway vehicles call for more horsepower, more speed, more work to be done. This means that off-the-road tires must be built for as much traction as can be developed from existing soil shear, and for higher and higher speeds. Heavy equipment is now built to move at 30 mph, and there are indications that soon this



Maximum safe operating temperature for tires made of today's commonly used materials has been established as 250 F, according to a Firestone report. Temperature of the tire is a function of load and speed. Plot shows the effect of speed on a normally loaded tire. At speeds considered normal in up-to-date operations, tire temperature comes dangerously close to the maximum allowable.

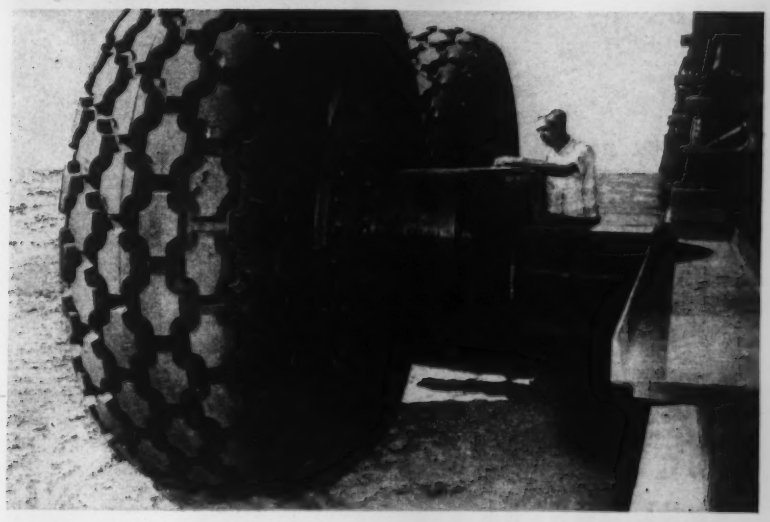


figure will approach 50. The conclusion is inescapable that users must be prepared to pay the penalty of shorter tire life.

Load and speed are the two factors that develop heat in a tire. Increase them both indiscriminately and tire heat gets out of control. When tread temperatures exceed 250 F, tires are subject to failure at the tread-body interface.

How do load and speed heat a tire? Load causes the tire surface next to the road to deflect out of round. Frequency of this deflection is identical to rpm of wheel which, in turn, is tied to speed. The result: Work absorbed by the tire appears in the form of heat.

How does design for traction affect tire temperature?

Any additional rubber in the form of tread, cleats, or lugs on the body of the tire forms a trap

Change in size may suit a tire to a new type of service. A giant Firestone "all weather" tire (above) has the flotation necessary for a desert job and wins approval over a special sand tire because of superior wear of the heavier tread. Goodyear "sure-grip" lugs on giant 8-ft tires (below) are said to reproduce the pressure of a camel's foot.

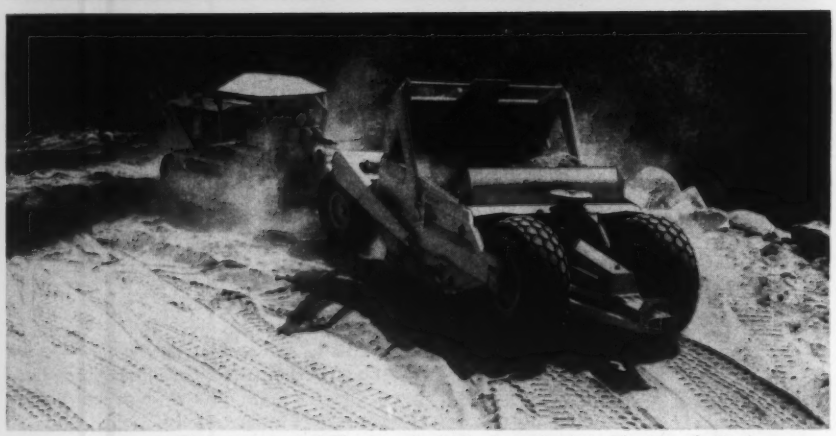
that interferes with dissipation of heat developed by tire work. Traction is produced by tire lugs that penetrate the ground and induce shear stress in an appreciable depth of soil. Length of lug is governed by its strength and flexibility, soil penetration the vehicle weight can produce, and need for adaptability to various jobs.

Short, wide lugs—called cleats or bars—are also used to protect the tire body from bruises or penetration, and a popular type of off-the-road tire is almost entirely covered with a patterned tread to give maximum flotation in shifting, sandy soils. Remove or thin down a lug and traction suffers. Shave down the cleats and the tire is more susceptible to damage. Broaden the interspaces in a patterned tread, and the tire loses flotation. The masses of rubber that trap heat on a tire surface are there for some good reason, and removing them to

THREE BASIC TREADS

For rocky ground there's a tire-tread form that has wide, closely spaced cleats whose chief function is to protect the carcass of the tire from damage by sharp rocks.

For maximum traction in soft, compressible ground, bars are narrower, more widely spaced to penetrate and take advantage of shear strength of a hunk of soil.



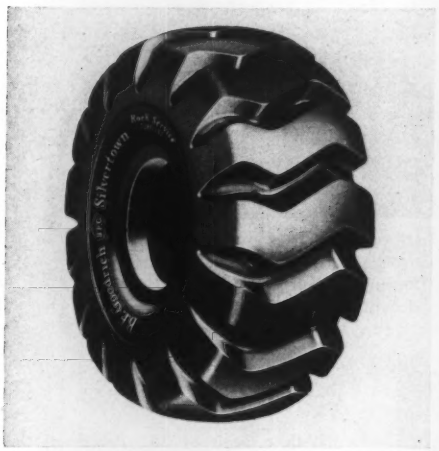
For shifting, unstable ground like sand, a closely spaced geometric pattern presents maximum surface contact for best flotation and least possible soil stress.

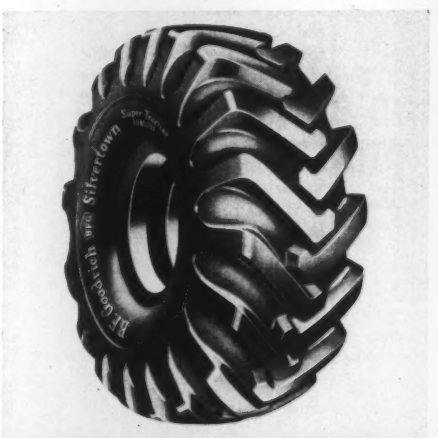
Photos courtesy of Firestone (top), Goodyear (center), Firestone (bottom),

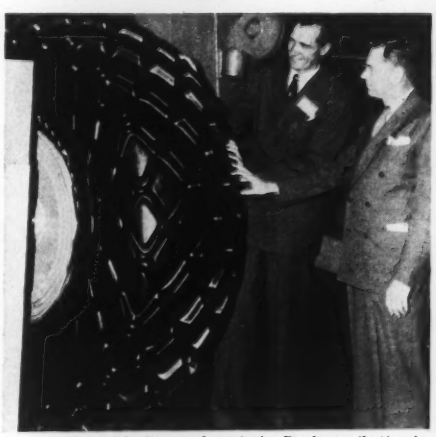
let heat escape means some sort of sacrifice of wear or life.

Where does this leave us?

Tire builders are not licked. Experts agree that the surface has just been scratched in off-the-road traction research. Lower pressure in tires can produce more deflection







Goodrich (top and center), Goodyear (bottom).

MORE USABLE HYDRAULIC POWER WHEN THE CONTROL ZONE IS WATERMAN

Waterman Valves and Accessories for Hydraulic Systems

Flow Regulators

Solenoid Valves

Filters

Check Valves

Pilot Checks

When you specify components for hydraulic systems—either mobile or stationary—give a second thought to the vital elements of the *Control Zone*. When you write in *Waterman* for DC or AC solenoid valves (like the ¾" No. 314 shown above), you specify many extra values that no other valves can give: Pilot operation, for wider valve opening, lower pressure drop, less power consumption; operating pressures up to 3000 p.s.i. with high-strength aluminum alloy bodies; easier installation; complete accessibility of all working parts; continuous-duty solenoids with modern plug-in connectors; fast, positive valve action. Every Waterman valve is factory-tested before shipment. And yet all this extra value costs you no more. Specify Waterman—and be *right . . . from the start.*

W-8910

Waterman representatives are in all principal cities. Write for Waterman Solenoid Valve Catalog No. 2000, and for Waterman Flow Regulator Catalog No. 1000. Also suppliers of AN and MS qualified flow regulators and fuses.

Waterman Engineering Company, 725 Custer Ave., Evanston, Illinois

Circle 414 on Page 19

and thus more ground-contact area. This can be translated into more traction and less penetration on soft soils, or loose, sandy soils. But at high speeds deflection means working of the tire body and consequent heat.

Present tire research is working at several levels:

- Stronger materials that heat less —withstand heat better.
- New tread and tire designs for cooler running—shallow skid and caved skid designs, for instance.
- Larger wheels; we have currently at least two "world's biggest" tires.
- Wider tires for more surface contact.

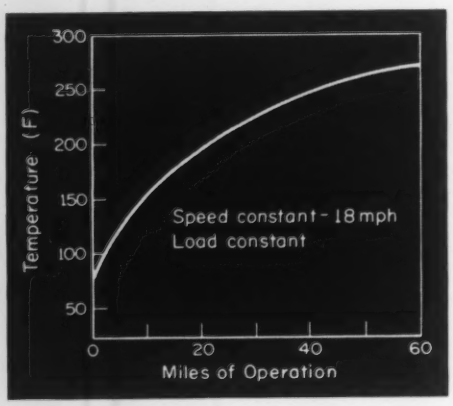
Flexible, strong materials that generate little heat when working, yet can operate at high temperatures are ideal for tire construction. Present rubbers are either high-temperature or abrasion resistant. A rubber that combined both features would increase tire life. Goodrich is announcing just such a rubber that will give off-highway tires 70 per cent longer life in severe rock service. A material that could stand higher temperatures, yet take the punishment that rayon and Nylon take would offer a welcome improvement in cord life. The advantages of Dacron cord are more in the realm of strength and freedom from "set." Nothing much has been said of its temperature limits.

Firestone is working on a caved cleat. Tests show the center of a cleat gets as much as 20 F hotter than the edge. By removing material from the center, they hope to improve heat dissipation without changing mechanical function.

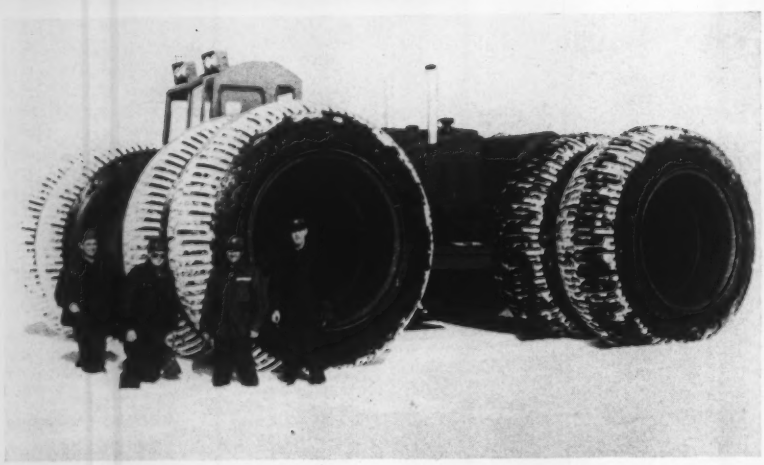
Tire makers foresee a sharp increase in tire diameter-to-load ratios. More specialized one-purpose vehicles with tires to match are on the way. Making them will call for closer co-operation between tire and vehicle designers.

Fewer free-rolling wheels and more power wheels will distribute traction loads now imposed on a few tires. Faster speeds will call for lighter tires with thinner carcasses and treads; the result will be some penalty in wear and durability. The present trend to more self-powered vehicles may eventually make all units self-contained.—T. M. LEACH

Caved cleats (left) may be one way to dissipate tire heat without sacrificing performance. Remaining cleat would bridge rocks. In conventional rock-service tire (center), Firestone found temperature differentials as much as 20 F between center and edge of tread. "Skinned down" tire (right) with reduced cleat and shoulder gages will sacrifice wear life for fast cool service.



With a limit of 250 F for top safe operating temperature, the plot shows that for tires, speed, and load used, the maximum safe haul would be about 40 miles. As speed, load, and length of haul are increased, this tire will have to be replaced by a better heat-dissipating tire that may not wear as long.



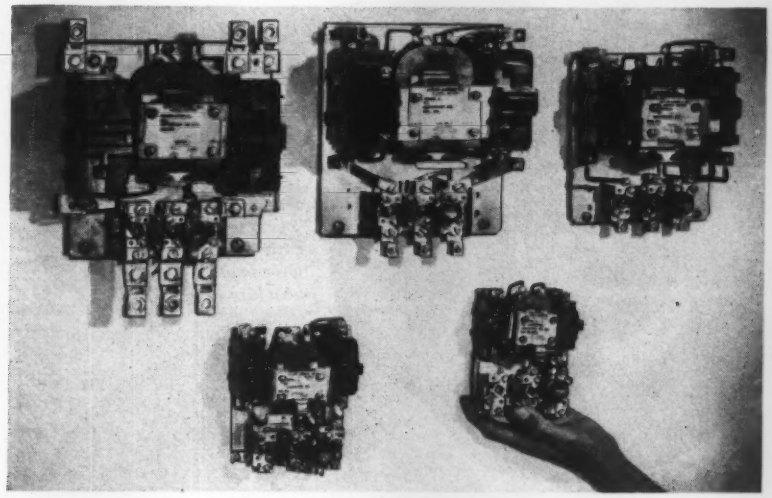
"Biggest tire" by (Firestone) is used for special-purpose vehicles and the Le-Tourneau-Westinghouse snow train that has already proved out in Arctic travel. With 10-ft diameter and 4-ft width, the tire is inflated to 5-lb-pressure to give giant vehicles a delicate step on fragile surfaces.

The Panelbuilder

87 YEARS OF SERVICE
CUTLER-HAMMER
CONTROL
C-H

News for and about Panelbuilders

Cutler-Hammer Inc., Milwaukee, Wis. • *Division:* Airborne Instruments Laboratory. • *Subsidiary:* Cutler-Hammer International, C. A.
Associates: Canadian Cutler-Hammer, Ltd.; Cutler-Hammer Mexicana, S. A.; Intercontinental Electronics Corporation,



COMPLETE LINE OF DEPENDABLE CONTROL COMPONENTS CUTS PANEL ASSEMBLY COSTS

Panelbuilders using Cutler-Hammer Three-Star Motor Control report it provides important savings in the time and effort required to layout, mount and wire their panels. Ready-to-mount Cutler-Hammer Starters and Contactors are available in NEMA sizes 0 through 4 for all non-reversing, reversing, and multi-speed applications.

Simplified Installation

Regardless of the size or type, all Cutler-Hammer Starters and Contactors use the same time-saving methods of key-hole mounting and straight-through wiring. Sure-grip terminal connectors hold wires securely even when different sizes are used. Indestructible molded magnet coils are color coded for quick voltage and frequency identification, and to interchange coils only a screwdriver is needed.

Dependable Performance

Repeated tests reveal Cutler-Hammer Components provide substantially greater electrical and mechanical life. Vertical dust-safe contacts stay clean, free from the ravages of arcing and pitting caused by dust contamination. Light weight, short stroke movable contact members hold the inertia effect to a bare minimum resulting in far less contact bounce and mechanical wear. Magnet armatures pivot smoothly on hardened bearing surfaces, avoids the uncertainties of sliding friction.

Complete information on all panel mounting Cutler-Hammer Control Components is contained in the latest edition of the Panelbuilders Handbook.

PANELBUILDERS HANDBOOK SIMPLIFIES SELECTION OF ELECTRICAL COMPONENTS

This handy 80 page reference guide is specifically edited to assist design engineers and control panelbuilders in the selection of electrical control components and control accessories. Every effort was made to make this book as concise as possible, and yet it includes such vital information as wiring diagrams, dimension drawings, ratings, ordering information and a maintained price list.

Address your request for a personal copy on your company letterhead. Ask for the Publication EE120- S243. . . . Cutler-Hammer Inc., Milwaukee 1, Wis.

NEW OIL-TIGHT POTENTIOMETERS

Cutler-Hammer recently announced the addition of oil-tight potentiometers to the very popular line of 10250T Oil-Tight Pushbuttons, Indicating Lights, Selector Switches, etc. Complete, ready-to-mount units are available in three models . . . a single element 2 watt potentiometer, a dual element 2 watt potentiometer, and a single element 25 watt potentiometer. All three models are so designed that they can be either base or one-hole mounted. Base mounting of the control units is gaining preference among panelbuilders and machine designers because it eliminates "hinge wiring" usually associated with one-hole, cover mounted control units. The new Cutler-Hammer Oil-Tight Potentiometers are easy to install and index. The operating knob, indicator

ring, and sub-panel operator are independently adjustable, permitting rapid, sure alignment of all three. The out-front position of the indicator ring is another plus feature of design. One glance and the machine operator is sure of the exact setting . . . no stooping, no parallax, no guessing. For detailed information on the new Cutler-Hammer Oil-Tight Potentiometers and other 10250T control units write on your company letterhead for the Master Design, Pub EL178- S243.

Circle 415 on Page 19

CIRCLE F

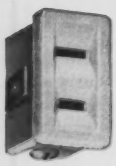
choice of
screw terminals
male tabs
wire leads
absolute ground

wherever the power supply must be grounded . . .

it's grounded best with Circle F's SNAP-IN U-GROUND CONVENIENCE OUTLET— listed both by UL and CSA. Specified for use on ranges, "power blocks," and many other applications, it has an all-bakelite body, double wiping contacts, a 15 Amp.-125 Volt rating and is available in grey, brown, black, and white. When you specify Circle F, you get precision-engineered devices of "custom-made" grade. Circle F's fast, quality-controlled manufacture takes less time *and guarantees lowest cost!*

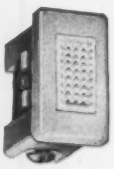
SNAP-IN U-GROUND CONVENIENCE OUTLET

APPLIANCE SWITCH
NO. 2230



CONVENIENCE OUTLET
NO. 340

CONVENIENCE OUTLET
NO. M438



PILOT LIGHT
NO. 490

MALE LOAD PLUG
NO. 344

keep your costs on the ground by specifying Circle F's quality-controlled snap-in devices. a model for every use.

CIRCLE F MFG. CO.

TRENTON 4, NEW JERSEY • For your wire requirements: Eastern Insulated Wire Corp., Box 591, Trenton, N. J.

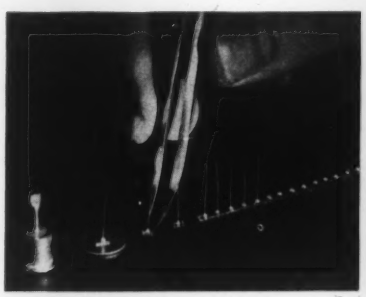
Circle 416 on Page 19

Marines To Test Air-Cushion Craft

WASHINGTON — Combat use of ground-effect craft is scheduled for early evalution by the Marine Corps. Two craft that obtain lift from downward-directed jets of compressed air are being purchased from National Research Associates Inc., Silver Spring, Md. Delivery of the first is scheduled for mid-September.

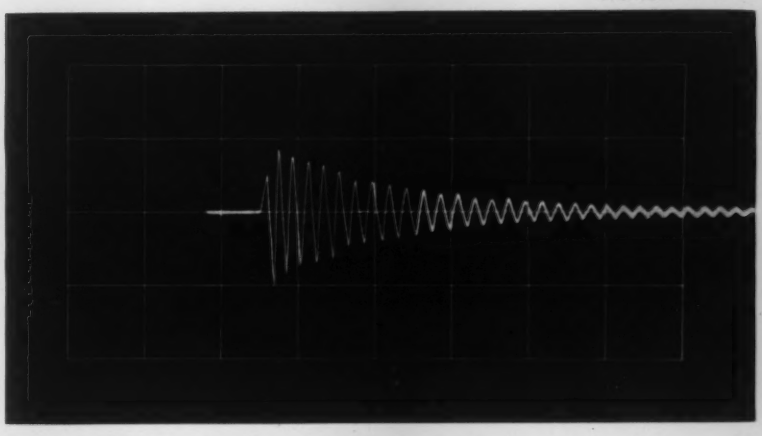
The vehicles, designed to "float" 9 to 15 inches above land or water and also to operate as conventional ground vehicles, derive both lift and lateral momentum from compressed air jets. Mounted at an angle 30 degrees from the horizontal, the jets allow forward, backward, and turning movements by means of adjustable vanes in each jet-discharge slot.

First models of the amphibious vehicles are designed for two passengers. Each will weigh about 1050 lb, and will measure about 14½ ft long by 8 ft wide by 3½ ft high. Power will be furnished by twin 40-hp, 6500-rpm engines. Construction will be of aluminum alloy and glass fiber.



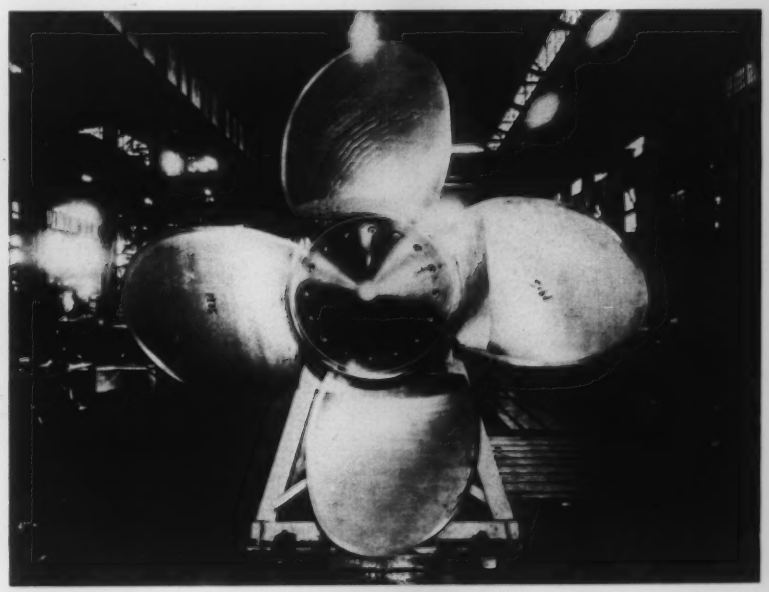
Dendrites May Speed Transistor Production

Fully automatic transistor production may result from the new method of growing germanium and other semiconductor materials discovered recently by Westinghouse research laboratories. "Hand-built" version, above, illustrates the process. Any number of devices can be built on the surface of a single dendrite to form a long continuous strip of semiconductor components, or individual units can be separated from the group by cutting the dendrite into small pieces. Mounting the semiconductor in a plastic or metal container completes the process.



Film Catches Single-Transient Traces

Single traces of 450-megacycle damped sine wave can be stopped by a new ultrafast photographic film. Film is reported to have excellent quality and sharpness. Announced by Polaroid Corp., Cambridge, Mass., the new film has an ASA daylight exposure index of 3000 and records oscilloscope writing speeds of 3000 cm per mu sec—8000 cm per mu sec if short developing times and prefogging techniques are used. It will record transients having a rise time of less than 1 milli-mu sec, much too fast to be seen by the human eye. In addition to uses in high-speed computers, high-frequency communications, and accurate timing devices, the film makes indoor flashbulb photography possible without flashbulbs. Normal indoor lighting (even after nightfall) and twilight lighting are sufficient for good pictures. It's packaged for regular Polaroid Land cameras.



Navy's Largest Controllable-Pitch Propeller

Ships can stop dead within two ship lengths using the Navy's largest controllable-pitch propeller. Recently declassified, the propeller increases maneuverability of ships ranging in size from tugboats to supertankers. Designed by Baldwin-Lima-Hamilton Corp., Philadelphia, the 9 ft 9 in. diam propeller absorbs 6859 shaft hp at a shaft speed of 300 rpm. Other models up to 28 ft diam are available in three alloys—Nialite and manganese bronze (for salt water application) and stainless steel (for fresh water application). Excellent maneuverability enables a ship to hover offshore, and to change course at high speed.

No favoritism here!

The umpire calls 'em like he sees 'em. He's paid to be objective, and that's why his opinions are far more reliable than those of a partial home team rooter.

Twin Disc can be as unbiased as an umpire when it comes to making recommendations about power transmission applications. The reason is simple: Twin Disc—and only Twin Disc—builds a complete line of industrial drives. Friction or fluid, there's a Twin Disc drive for every power train . . . in capacities from fractional to 1000 horsepower.

So no matter what unit the Twin Disc application engineer advises for your drive line, he's playing no favorites—his company makes them all. For an honest and completely objective answer to your problem, get in touch with Twin Disc now.

FLUID OR FRICTION

Fluid couplings

Single-stage torque converters

Three-stage torque converters

Mechanical clutches

Hydraulic clutches

Electric clutches

Air-actuated clutches

TWIN DISC
CLUTCHES AND HYDRAULIC DRIVES
REG. U.S. PAT. OFF.

TWIN DISC CLUTCH COMPANY • RACINE, WISCONSIN
Hydraulic Division: Rockford, Illinois

Circle 417 on Page 19

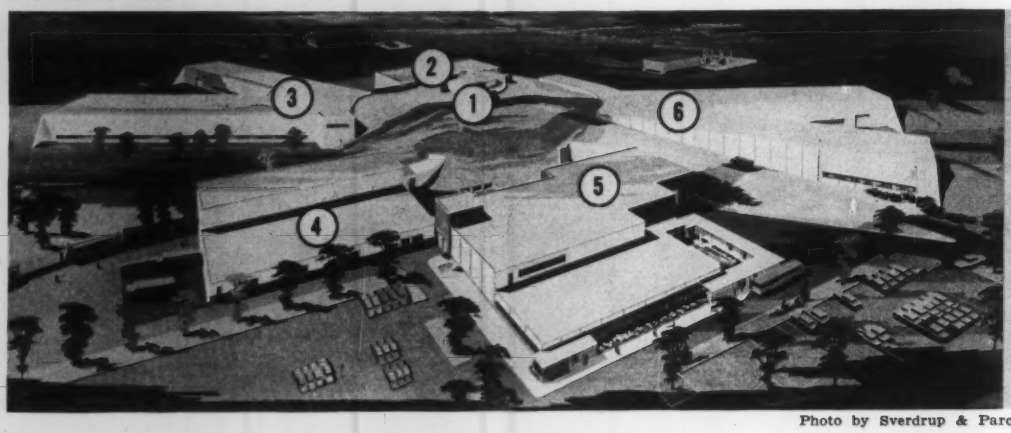
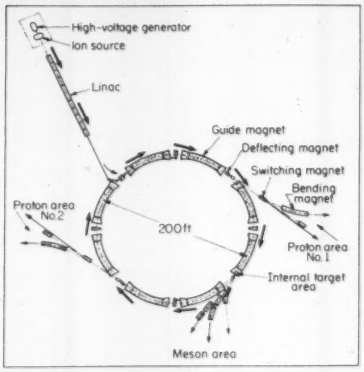


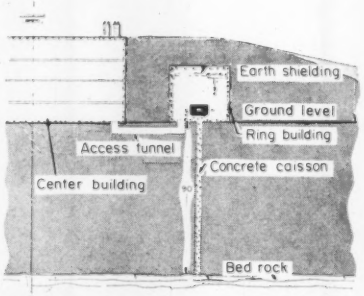
Photo by Sverdrup & Parcel Engineering Co.

ZGS

Midwestern Atom Smasher Will Produce All "Wonder Particles" Of Atomic Physics



Argonne's accelerator is designed so that whirling particles can be shunted into experimental areas at any time after they enter the synchrotron. Two proton buildings and a meson building will receive these particles. In these buildings they will be used in experiments on the nucleus.



Accelerators will be underground to protect experimenters against radiation.

SYNCHROTRON designers are faced with a compromise: They can design a machine to accelerate a few protons (to the physicist, a *few* protons means a *few billion*) to a tremendous speed; or they can design one to accelerate many more protons to a speed not quite as high. Their decision depends on how the machine will be used.

Zero Gradient Synchrotron (ZGS) now under construction at Argonne National Laboratory, Lemont, Ill., is one of the latter type. It is designed to accelerate many protons to energies up to 12.5 billion electron volts. Protons with this much kinetic energy become atomic "bullets" and are used to smash target atoms. This $29-million laboratory tool will shatter nuclei into all the "strange" and exotic subparticles that exist in the heart of the atom.

Protons will first be accelerated to 800 kv by a standard high-voltage source. Then they will go into a linear accelerator (Linac)— a smaller atom smasher in which particles travel in a straight line rather than whirling in a circle. Protons accelerated to 50 million electron volts in the Linac will then be introduced into the synchrotron in short, well-regulated bursts. There they will attain 12.5 billion electron volts.

As a particle source, ZGS will produce all 30 presently known or anticipated atomic particles—only three of which are stable in nature. It is expected to produce even the heaviest particles, including antiprotons, anti-neutrons, and hyperons (unstable particles heavier than the neutron), and all six of the postulated anti-hyperons. Further, it may produce new particles for which there is presently no evidence of existence.

The machine's second job will be to serve as a "microscope" for examining subnuclear systems. Beams produced will be used for exploring behavior of particles interacting at very short distances. Physicists are now aware of several types of forces — gravitational, electromagnetic, and both "strong" and "weak" coupling forces which bind the atomic nucleus and govern decay of neutrons and many other particles.

The ZGS machine will fill a gap in the nation's peaceful uses of the atom program. It will make a high-energy accelerator available to midwest scientists who previously had to either schedule experiments at a distant laboratory or else abandon them entirely.

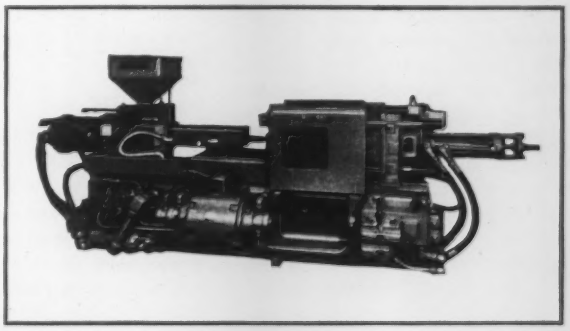
NOW! Let General Electric ECONO-MATCH Motors to Meet Your Specific Drive Requirements

You have over *three billion* different designs and types of integral hp a-c motors to choose from. And, it is increasingly difficult and costly to make this choice. It will pay you to find out how General Electric engineers can do this motor selection job for you.

THIS NEW MOTOR SELECTION SERVICE, ECONO-MATCHING, is the perfect matching of motor to machine and application for over-all economy, improved machine performance and greater reliability.

HOW ECONO-MATCHING WORKS—G-E engineers work closely with your designers studying machine characteristics: speed, torque, duty cycle, life expectancy, environmental conditions, etc. Then, through use of computers and advanced design techniques, General Electric can supply exactly the motor required for your job.

FOR EXAMPLE, the Reed-Prentice injection molding machine, shown at right, had been using a standard 40-hp motor. By ECONO-MATCHING, G-E engineers determined that a smaller, lighter, more compact 30-hp motor with improved electrical characteristics could do the job required. Although this special 30-hp motor cost slightly more than a standard 30-hp, it provided greater efficiency and cost considerably less than the 40-hp motor it replaced. It also cut space and weight requirements. G-E has also ECONO-MATCHED motors for crane, compressor, and other applications.



GENERAL ELECTRIC

MAIL THE ATTACHED COUPON TODAY . . .

or call your nearby General Electric Apparatus Sales Office for complete information on how G-E can ECONO-MATCH a motor to meet your specific requirements.

Circle 418 on Page 19

Section 891-21B
GENERAL ELECTRIC CO.
Schenectady, N. Y.

Please furnish more information on how you can ECONO-MATCH a motor for my application which is_____

NAME_____ TITLE_____

COMPANY_____

CITY, STATE_____

Fatigue Life and Safety Stressed in DC-8 Design

Cabin Operational Life Exceeds 100 Years in Tests

LONG BEACH, CALIF.—Project super safety might well have been the code name for the design and development of the DC-8 jetliner. Because the new airplane will operate at extremes of altitude, speed, and temperature, structural design was given as much attention as aerodynamic design. All this was done without benefit of a prototype aircraft. The first DC-8 took to the air while assembly operations were under way on number 14.

The three commercial versions of the Douglas-built airplane all have identical dimensions and utilize the same tooling. Major differences between the three are in wing-skin thickness and in strengthening to accommodate higher gross weights. Of the three, the "domestic" model is intended for the shortest range, and the "intercontinental" and "extended range" models for successively longer ranges.

Major attention was devoted to wing-root design. Conventional bending loads on straight wings are transposed into bending and torsional loads at the root section of swept wings. This factor coupled with gust loading stresses encountered at the altitudes and speeds flown by the aircraft make fatigue life critical in the wing root.

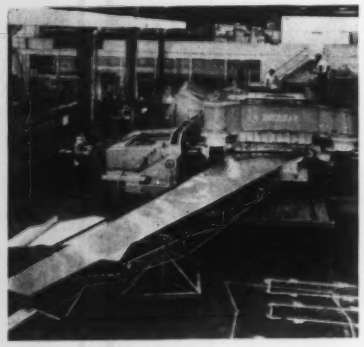
Wing skins, spars, and other members are tapered to provide minimum weight in areas of reduced load, and maximum strength in areas of heavy loading. Wing skin is thickest at the root and across the fuselage where high loads are located.

Fail-safe design in the cabin includes holes coined to increase fatigue life by reducing stress concentrations in regions where testing has indicated unusual stresses to be present. In addition, the fuselage outer skin is reinforced by strategic frames both around the door and elsewhere. High-tension fasteners secure window frames to the fuselage assembly. Forward sections of the fuselage are covered by extra-thick skin because stresses are about double those of the rearward sections. In order to provide as aerodynamically clean a nose section as possible, the titanium skins are spot-welded to eliminate rivets and screws from the cowl and pod doors.

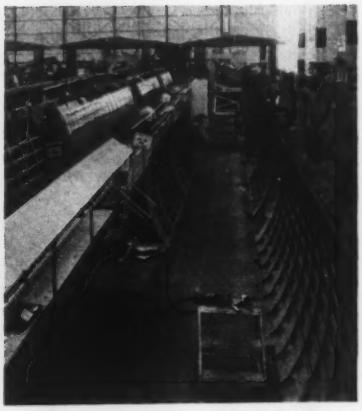
Test facilities reproduce more severe conditions than the DC-8 is expected to ever encounter in flight. An elaborate control system allows testing of hydraulic and manual controls for coordination in a wide variety of flight load conditions. During hydrostatic tests simulating more than 120,000 flights, a single DC-8 pressure-cabin withstood the equivalent of over a hundred years of normal operation.

Testing of the aircraft was begun more than a year ago.

Titanium bands, riveted 18 in. apart around the circumference of the forward section, serve as "rip-stoppers." Titanium is more resistant to cracks than aluminum or stainless steel.



Wing skin starts as aluminum alloy sheet. The sheet is gripped by four jaws while hydraulically powered clamps fix the skin against spanwise movement. Each jaw pulls with a force of 300 tons to stretch-form the sheet into the proper shaped airfoil.

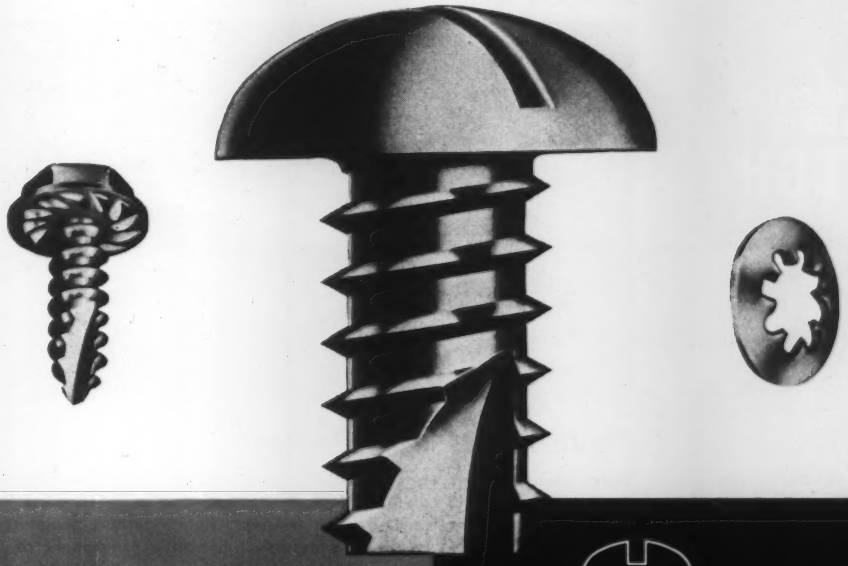


Rip-stoppers reinforce the cabin skin at strategic frames and surround every door and window. Window frames are solid, tapered, and blow-out proof and are fabricated from a single piece of aluminum stock.

Structural materials in the tail section also double as sound insulation. The concept of extra-thick plating and longitudinal stiffeners to deaden aircraft noise is pioneered in this design.

ASME Drafts Terminology For Automatic Controls

Proposed standard on Terminology for Automatic Controls is being distributed for criticism and comment by American Society of Mechanical Engineers. Interested persons may obtain free copies of the tentative draft by addressing Frank Philippbar, American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.



HOW TO SELECT COST-SAVING

fasteners for plastic

A TYPICAL EXAMPLE:
Cuts its own thread—

Shakeproof's® Type 25 Thread-cutting Screw saves time because it eliminates tapping. Blunt point assures maximum thread engagement and high holding strength when driven into a relatively thin panel.

Shakeproof has pioneered in developing ingenious, cost-cutting fasteners for plastic applications. The screw featured above not only taps its own hole—often it eliminates costly threaded inserts. Another Shakeproof development, the Type 17 self-drilling Nibscrew®, both drills and taps as it is driven. A Shakeproof Dished Lock Washer compensates for differential in expansion between plastic and metal . . . temperature changes won't loosen the assembly.

For highest quality fasteners that assure faster assembly and lower costs investigate the Shakeproof line. There's a Shakeproof fastener to meet your need—or Shakeproof engineers will develop one for your specific application.

WRITE FOR NEW SHAKEPROOF BULLETIN NO. 300
Shakeproof Bulletin 300 shows ten typical, profitable applications of Shakeproof fasteners on products using plastics. Offers free samples for testing. Send for your copy now.

SHAKEPROOF
"FASTENING HEADQUARTERS"®
DIVISION OF ILLINOIS TOOL WORKS
St. Charles Road, Elgin, Illinois
In Canada: Shakeproof/Fastex
Division of Canada Illinois Tools Limited, 67 Scarsdale Road, Don Mills, Ontario

Circle 419 on Page 19

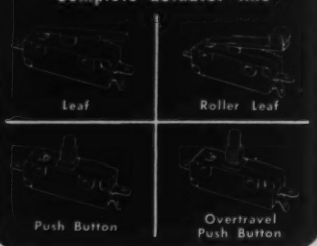
NEW!
LOW COST—PRECISION
SNAP-ACTION
SWITCH

E13-00A
SERIES

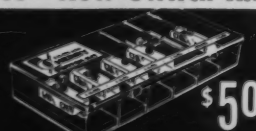
featuring --

- .100 minimum overtravel
- wear resistant nylon button
- environment resistant interlocking case
- standard case and mounting dimensions
- unique snap-action mechanism
- UL rated: 15 amp 125 250 V a-c ¾ hp 125 V a-c, 1½ hp 250 V a-c

Complete actuator line



Plus -- New Switch Kit!



$5.00

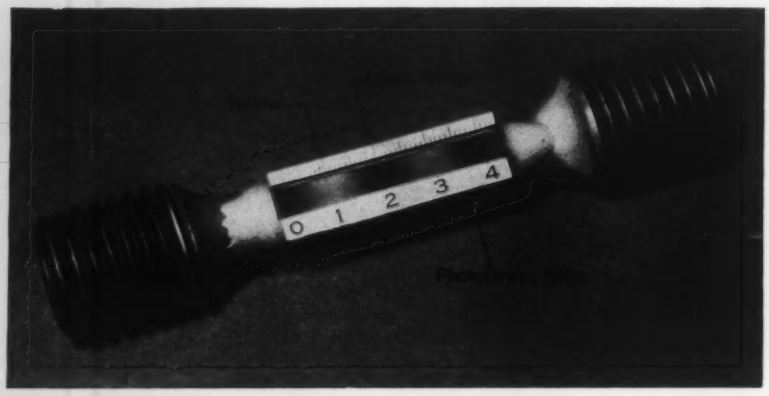
On hand . . . a complete switch line in a handy, compact plastic kit. It's convenient, flexible and economical. Ready for proto-type or emergency use. The kit contains: Five switches including Push Button, Over-travel Push Button, Leaf, Roller Leaf and basic switches plus extra leaf and roller actuators. Ideal for replacement, experimental or development use. Order yours today!

Contact Cherry with any of your switching problems. Over 8,000 switch variations available to meet specific application requirements.

CHERRY

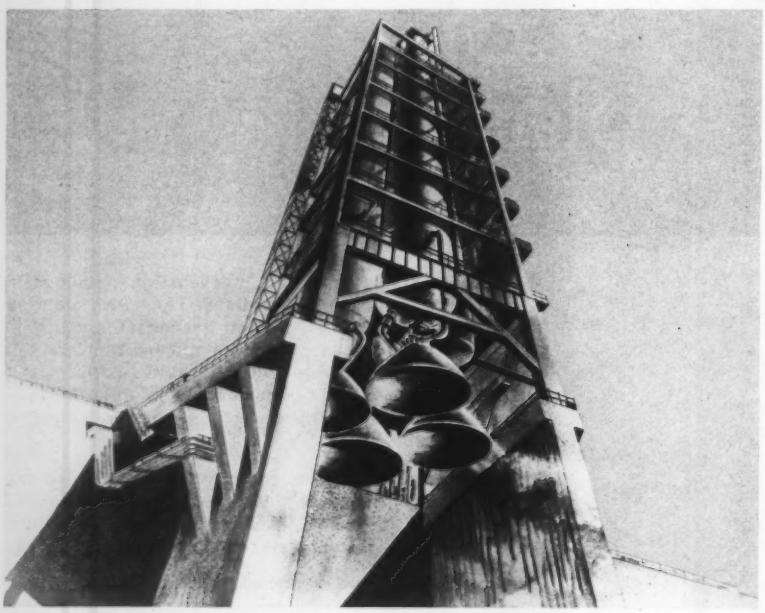
CHERRY ELECTRICAL PRODUCTS CORP.
1643 Deerfield Rd. Highland Park, Ill.

Circle 420 on Page 19



Photoelastics in a Package

Stress measurement on a budget is promised by a new packaged PhotoStress gage. Needing no auxiliary instrumentation, the gage converts either static or dynamic strains into shifting color fringes. Readings can be interpreted visually in terms of stresses, loads, or pressures. Sensitive component of the gage is a thin plastic rectangle, mirrored on one side, coated with a polarizing material on the other. Bonded to a structural or machine part under load, the gage distorts axially in tension or compression. Fringe shifts—which are directly proportional to strain—are measured against a graduated built-in scale. Tatnall Measuring Systems Co., Phoenixville, Pa., developer of the gage, makes four models with strain sensitivities ranging from 20 to 40 microinches per inch.



Free World's Largest Rocket Test Stand

Four rocket engines, each rated at 1.5 million lb thrust, will be fired simultaneously on a new rocket test stand. The concrete and steel test facility will be the most powerful in the free world. Designed by Aerojet-General Corp., Azusa, Calif., it is to be constructed at Edwards Air Force Base. When completed, it will tower eight stories high and will have a 60-ft square opening for the rocket engines' fiery exhaust. Cooling water will be dumped on the deflection apron at a rate of 75,000 gal per min. A basin below the stand will collect the water for reuse. Construction will be started late this year.

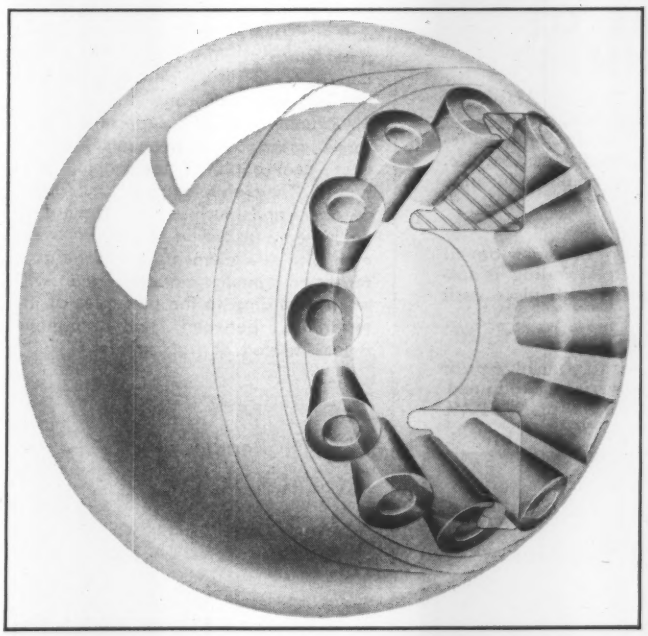
TEAR OUT AND PUNCH AS INDICATED FOR YOUR FILE

TEAR OUT AND PUNCH AS INDICATED FOR YOUR FILE

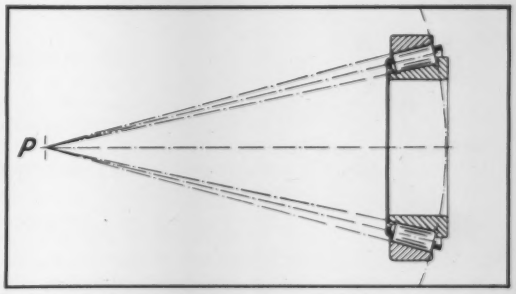
One in a series of technical reports by Bower

BEARING BRIEFINGS

SPHERICITY — ESSENTIAL TO MAXIMUM BEARING PERFORMANCE



When you require bearings, we suggest you consider the advantages of Bower bearings. Where product design calls for tapered or cylindrical roller bearings or journal roller assemblies, Bower can provide them in a full range of types and sizes. Bower engineers are always available, should you desire assistance or advice on bearing applications.



True rolling of tapered bearing elements depends upon maintaining a true spherical radius during manufacture.

For a tapered roller bearing to achieve maximum performance, i.e., maximum life and capacity under load, it must have true sphericity — a condition of bearing geometry which permits true rolling of the tapered rollers in the raceway.

True rolling in tapered bearing elements is the result of maintaining a critical geometric relationship between the raceways and the contact surfaces of each roller. True rolling is essential to maximum performance. Without it, premature bearing failure is certain.

As engineers know, a tapered roller will describe a true circle when rolled on a plane surface. *It will always roll in this one path precisely, without sliding or skewing.* But to put true rolling to work in a bearing which can carry both heavy thrust and radial loads, it is essential that the rollers *and* the raceway have a true spherical radius, or sphericity. The drawing illustrates this condition.

If each roller in the bearing were to be extended in length, while retaining its taper, it would form a cone, terminating at point "P". All cones generated from all rollers would meet at point "P", which is also the center of the hypothetical sphere shown. The surface of the sphere would *touch all points on each roller's head!*

In effect, then, each roller's taper determines the radius of a hypothetical sphere whose surface, in turn, determines the correct contour for each roller head. Only when these conditions are satisfied in design, and when they are rigidly held during manufacture, will true rolling take place. In the manufacture of each Bower tapered roller bearing, sphericity is held within extremely narrow limits by means of special Bower-designed precision grinders. The consistent accuracy possible with these machines is one major reason why Bower roller bearings provide maximum performance under all speeds and loads up to the bearing's maximum rating.

BOWER ROLLER BEARINGS

BOWER ROLLER BEARING DIVISION — FEDERAL-MOGUL-BOWER BEARINGS, INC., DETROIT 14, MICHIGAN

Circle 421 on Page 19

WAPAK HARDENED WAYS LAST LIFETIME OF YOUR MACHINES

Engineered from solid tool steel, WAPAK Hardened Ways are uniformly hard through and through . . . No galling, scoring or other failure throughout lifetime of your machines . . . even under rugged service. Carburized or laid steel ways also available in some sizes.

MICRO-GROUND FINISH

Utmost care is given to accuracy of finish on all WAPAK Hardened Ways. Micro-Grinding is followed by individual inspection of each piece with Profilometer.

ENGINEERED TO SPECIFICATIONS

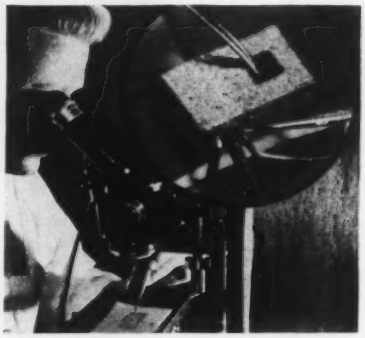
WAPAK Ways are manufactured to your blue print specifications and normal deliveries maintained. Your machines are more reliable with WAPAK Hardened Ways.

THE WAPAKONETA MACHINE CO.

Knives Engineered for the Job Since 1891

WAPAKONETA 9, OHIO

Also manufacturers of SLITTER KNIVES • SHEAR BLADES • ROTARY SHEAR KNIVES • SCRAP CHOPPERS • HARDENED SPACERS • GIBS • ROCKER PLATES • WEARING PLATES • BALL RACES • WEAR STRIPS • MACHINE LINERS • MACHINE KNIVES for all industries.



Microscopic Memory Cells

New memory and reasoning elements for electronic computers are so small that 5000 of them can be held in the palm of the hand. Developed by Aeronutronic, Div. of Ford Motor Co., Newport Beach. Calif., the elements are described as ultra-high-speed devices for computer operation. Known as BIAX units, they are expected to become principal components in the next generation of electronic computers. They should result in faster, cheaper, and much smaller computing equipment, according to Ford spokesmen. The new elements are made of a ferrite magnetic material and will work according to the principles of interference between two magnetic fields induced at right angles.

Chrysler Readied For Salt Assault

Seven-Stage System Set To Anti-Rust '60 Cars

DETROIT—Every car body in Chrysler's 1960 line will be subjected to three metal cleaning baths, seven anti-corrosive dips, seven spraying operations, and seven external paint-finishing operations before it gets the first coat of big-city salt.

The new rustproofing system was perfected after four years of laboratory testing and a quarter million miles of test driving on water-splashed chloride-treated roadways, according to R. S. Bright, group vice president, manufacturing.

The anti-corrosion phase alone takes an hour and 45 min to complete on a roller-coaster conveyor encased in a tunnel more than 2300 ft long. Some 60 cars an hour will travel through the system.

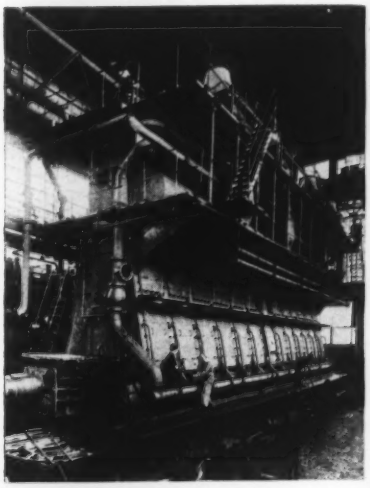
The process begins when steel arrives in coils and sheets from the

mills. It is given three intensive spray baths of caustic metal cleaner to remove all traces of oil and dirt. Then a special drawing compound is coated on the new metal as it moves into the blanking and stamping machines and on into the body-building departments.

When the body of the car has been completed, it moves along the assembly line to the anti-corrosion tunnel, where rustproofing really begins.

Here, the body is alternately cleaned, dipped, baked, sprayed and dried. It gets a phosphate coating, chromic-acid bath, and a layer of heavy, water-reducible primer. Temperatures during these operations are closely monitored.

The body is then ready for external finishing. This includes two coats of epoxy primer, oven baking at 350 F, wet sanding, first and second coats of lustre-bond enamel, and oven baking at 250 F to complete the job. Only Imperials, previously, were treated so well.



Slated for Second Place

A two-stroke giant now under construction at Burmeister & Wain, Copenhagen, Denmark, is expected to be the world's largest marine diesel. Bore will be a little more than 33 in.; stroke, close to 71 in. Largest marine diesel at present is this 12-cylinder unit developing 15,000 bhp at 115 rpm. The new unit will develop 17,300 bhp at 110 rpm. It will be installed on a 49,500-ton Norwegian tanker.

Chemically Inert Dry Bearing Material

Chemloy 719*

use without lubricant!

Chemloy 719 is proving to be the most *universal* dry bearing material ever offered to industry:

. . . because its extremely low coefficient of friction invites use where lubrication is impossible, impractical or undesirable.

. . . because it may be used on both sliding and rotating applications over a wide temperature range.

. . . because it is impervious to practically all known chemicals, solvents or corrosives.

. . . because it is excellent under vibration or shock service conditions.

. . . because it will not conduct electricity or cause galvanic corrosion.

Chemloy 719 is available in all basic forms—such as sheet, rod or tubing—or in parts molded or machined to specifications. Get full details.

*The best in Teflon based bearing materials.

Request Bulletin T-120 and Price Sheet No. 126, or send b/p specs. for quotation on molded or machined parts. Crane Packing Company, 6425 Oakton St., Morton Grove, Ill. *(Chicago Suburb). In Canada: Crane Packing Co., Ltd., Hamilton, Ontario.*

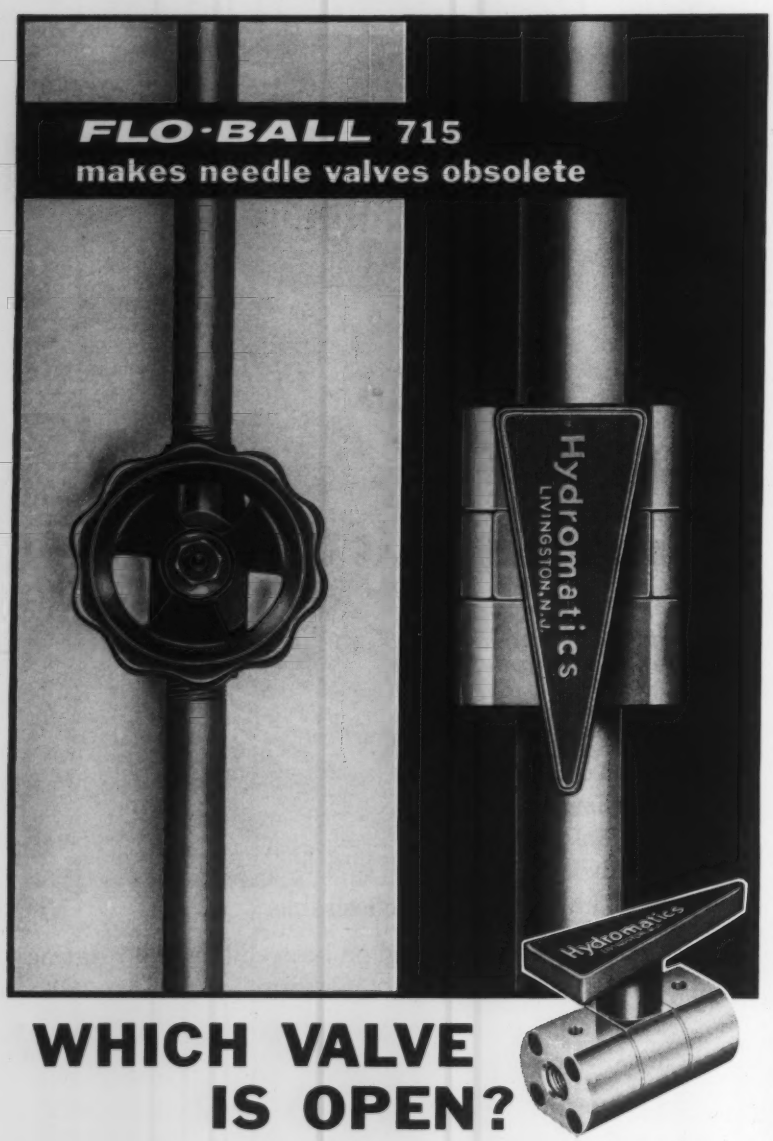
Teflon is a DuPont Trademark

John Crane

MECHANICAL PACKINGS SHAFT SEALS TEFLON PRODUCTS LAPPING MACHINES THREAD COMPOUNDS

CRANE PACKING COMPANY

Circle 423 on Page 19



WHICH VALVE IS OPEN?

They both are . . . but only the Hydromatics ***FLO•BALL 715,*** on the right, shows its position at a glance! A fast **quarter** turn moves it from open to closed position—instant action at flow pressures up to 3,000 psi with just 4 inch-pound torque. The ***FLO•BALL's*** exclusive straight-thru design has 100% flow efficiency—more than double the flow of needle valves!

Ideal for leakproof control of air, vacuum, steam, water, fuels, oils, kerosene, alcohol, etc., the ***FLO•BALL*** features zero leakage, universal mounting, removable flanges, and all stainless steel construction.

Write today for a complete catalog describing this valve and others for corrosive and cryogenic media. Also special designs for throttling flow control.

The *FLO•BALL* costs no more than old fashioned screw-type valves!

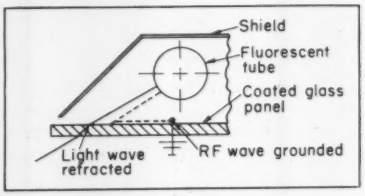
Exceptional engineering employment opportunities—write today!

Hydromatics, Inc.

FLO-BALL

LIVINGSTON, N. J. • WYMAN 2-4900 • TWX=LIVINGSTON, N. J. 120

Copyright 1959 Hydromatics, Inc.



Lamp Panel Grounds RF

Lamp-generated radio-frequency interference is filtered by a new glass lighting panel that transmits 75 per cent of the incident fluorescent light. Developed by Corning Glass Works, Corning, N. Y., the panel is coated on one side with a thin and transparent electrically conductive film. The film is electrically grounded to intercept radio waves and "steer them down the drain." Corning engineers expect the panel to find use in laboratories, hospitals, and wherever else rf effects on electronic equipment are undesirable.

Awards For Engineers Approved by House Committee

Worthy Engineers May Receive Medals, Tax-Free Dollars

WASHINGTON — Engineering contributions by individuals may soon be officially recognized by the government. A program approved by the House Committee on Science and Astronautics calls for the presentation of a medal by the President and up to a $10,000 tax-free stipend to not more than 20 deserving engineers each year.

Purpose of the program is to award engineering effort and to encourage individuals to embark upon an engineering career. As stated by Mr. Paul H. Robbins, executive director of the National Society of Professional Engineers, before the Committee: National emphasis on engineering contributions to our economy and defense effort is as important as emphasis on pure basic research.

"Much of our progress in developing guidance systems and advancing our missile program is dependent upon the practical application of known scientific principles. While no informed person can minimize the tremendous importance of basic research, we cannot fail to acknowledge the contribution of those whose individual life-

work is concerned with collecting that mass of knowledge derived from basic research and actually developing from it objects of practical application.

"The proposal before this Committee provides an excellent mechanism for calling public attention to the vital role which engineers and engineering will continue to perform in our over-all technological progress."

Missile Guidance System Fixes On Earth and Sun

PHILADELPHIA—New missile navigation system brings space travel one step closer to practicality. The new system focuses on two semi-fixed reference points in checking a missile's flight path and calling for course corrections.

One reference point is the earth's horizon. After the missile is fired, a wide-angle infrared-scanner locates the horizon, i.e., the curvature of the earth, by the large amounts of earth-radiated infrared in comparison to the little infrared present in space. When the scanner detects the combination of high and low intensities, it "locks on" the position and triggers compressed gas jets to get the vehicle back on course should readings start to vary.

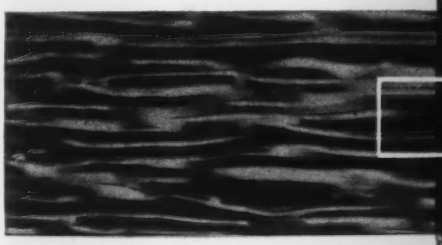
A sun-tracker provides a second "fix." After the vehicle has locked on the earth's horizon, a second set of gas jets fire to give it a revolving motion. When the tracker is facing the sun, the revolving motion is stopped. It also calls on corrective gas jets to keep the missile on course. The device is composed of heat-sensitive materials whose electric resistance changes when exposed to sunlight. Resistance changes cause triggering of the jets.

The system has been tested and proved successful in some of the latest missile firings. It was designed and developed by General Electric's Missile and Space Vehicle Dept. While not directly suitable for interplanetary navigation — because the earth and the sun would no longer be fixed points—it is the first step toward developing a successful system of this type.

ARDMORE TEXTURED METALS

from the most progressive producer of TEXTURED METALS comes dazzling new

TEXTURE TONE



upper left
Bristol Texture

lower right
Dunhill Texture

Texture Tone finish is available in many colors including Silver, Gold, Copper, (shown above) Green, Red and Blue.

You'll note your product takes on a distinguishing aire of quality, an uncommon "feel" of value, and excites a sudden spurt in sales—when you incorporate Texture-Tone in your product design. This adaptable new finish, applied to lustrous tin-coated steel, can be formulated to comply with your requirements (i.e. elasticity, resistance to abrasion and humidity, etc.). Although it is extremely durable and distinctive in appearance, Texture-Tone is surprisingly inexpensive...as low as 12c per square foot in quantity. Choose from a galaxy of colors and textures.

Ardmore Textured Metals are available in all metals, solid or perforated. Eight new exciting textures in sheets up to 52" in width or continuous coils to 48" width. Multiples, blanks or finished parts are furnished to your specifications.

Send today for this new 6 page brochure which describes in detail all of the textures and finishes available (including Texture Tone) together with photos of production applications in all industries.

ARDMORE PRODUCTS, INC.

1919 ALDENE ROAD • ROSELLE, NEW JERSEY

Telephone: In New Jersey — CHestnut 5-5400 • In New York — DIgby 9-0636

Circle 425 on Page 19

This tiny brass nut is mass produced to Class 3 tolerances for use in precision instruments. Typical of the miniature nuts FISCHER supplies to manufacturers of electrical and electronic equipment, it is countersunk both sides, burrless, cleaned and ready to install.

As the leading producer of *turned* nuts, FISCHER can supply standard, special and odd sizes or types of miniature brass nuts having diameters from ⅛" and threads from No. "O". All FISCHER nuts are made to exact customer specifications . . . and are competitively priced with nuts made by less precise methods.

If you need precision nuts . . . brass or aluminum . . . FISCHER is your best source.

there's no premium for precision at

Fischer SPECIAL MFG. CO.

451 MORGAN STREET • CINCINNATI 6, OHIO

8496-FS

Circle 426 on Page 19

Adhesives Institute To Be Held at U of W

MADISON, WIS.—Solutions to problems encountered in design and fabrication with adhesives, trouble-shooting adhesive bonds, and future uses for adhesives to improve product quality or reduce product costs are subjects to be discussed at the Industrial Adhesives Institute, which will be held at the University of Wisconsin Oct. 1 and 2.

The meeting will be sponsored by the university's Engineering Institutes, in co-operation with the Glues and Gluing Div. of Forest Products Research Society and the Forest Products Laboratory. Further information can be obtained from Richard A. McCormick, Institute Co-ordinator, 4016 Stadium, University of Wisconsin, Madison 6, Wis.

Meetings and Shows

Sept. 14-17—

Society of Automotive Engineers Inc. National Farm, Construction, and Industrial Machinery Meeting (including production forum and engineering display) to be held at the Milwaukee Auditorium, Milwaukee. Further information is available from SAE, 485 Lexington Ave., New York 17, N. Y.

Sept. 16-17—

American Die Casting Institute. Annual Meeting of the Institute and its research arm, the Die Casting Research Foundation, to be held at the Edgewater Beach Hotel, Chicago. Additional information is available from institute headquarters, 366 Madison Ave., New York 17, N. Y.

Sept. 17-18—

American Society of Mechanical Engineers — American Institute of Electrical Engineers. Engineering Management Conference to be held at the Statler Hilton Hotel, Los Angeles. Additional information is available from Meetings Dept.,

ASME, 29 W. 39th St., New York 18, N. Y.

Sept. 18—

Malleable Founders Society. Industry Meeting to be held at Hotel Sheraton-Cleveland, Cleveland. Additional information is available from society headquarters, 781 Union Commerce Bldg., Cleveland 14, Ohio.

Sept. 20-23—

American Society of Mechanical Engineers. Petroleum Mechanical Engineering Conference to be held at the Rice Hotel, Houston. Further information is available from Meetings Dept., ASME, 29 W. 39th St., New York 18, N. Y.

Sept. 20-25—

Instrument Society of America. Instrument-Automation Conference and Exhibit to be held at the Palmer House and the International Amphitheatre, Chicago. Additional information can be obtained from ISA headquarters, 313 Sixth Ave., Pittsburgh 22, Pa.

Sept. 21-22—

Standards Engineers Society. Eighth Annual Meeting to be held at the Somerset Hotel, Boston. Additional information can be obtained from Charles T. Ajamian, P. O. Box 538, Wayland, Mass.

Sept. 21-22—

Steel Founders' Society of America. 57th Fall Meeting to be held at the Homestead, Hot Springs, Va. Additional information is available from society headquarters, 606 Terminal Tower, Cleveland 13, Ohio.

Sept. 23-25—

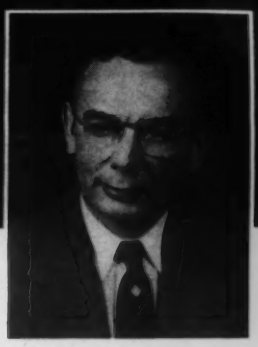
American Institute of Electrical Engineers—Institute of Radio Engineers. Nonlinear Magnetics and Magnetic Amplifiers Conference to be held at the Shoreham Hotel, Washington, D. C. Further information is available from AIEE headquarters, 33 W. 39th St., New York 18, N. Y.

Sept. 28-Oct. 1—

American Welding Society. Fall Meeting to be held at the Sheraton-Cadillac Hotel, Detroit. Further in-

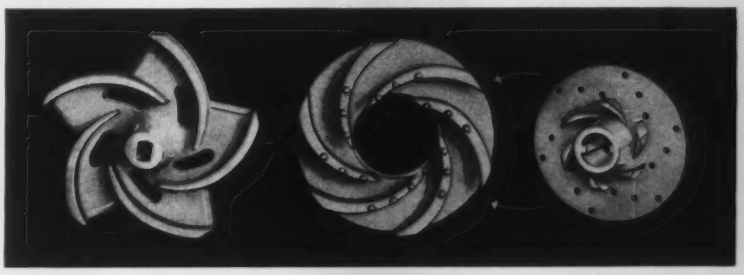
Circle 427 on Page 19→

profiles in plastics



by **B. FRANK HANTZ,** *Vice President*
AMERICAN INSULATOR CORPORATION
One of The Men Behind The Man From Aico

"Aico's enviable position in the field of molded plastics has been attained largely through customer satisfaction and service. Since 1916, Aico has been a major supplier of molded plastics to many of America's pace-setting industries. Each molding job presented its own unique problems . . . problems which were successfully solved by the integrated facilities and coordinated skill of expert craftsmen within the Aico organization. Perhaps the best proof of Aico's efficient service . . . and satisfaction delivered . . . is the record of new assignments we receive from customers we've served in the past."



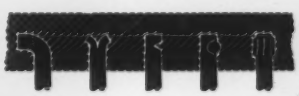
MOLDED NYLON PUMP IMPELLERS ANOTHER NEW USE OF AICO PLASTICS

These nylon pump impellers are typical examples of how better products result from the use of Aico Molded Plastics. Molded to extremely close tolerances, providing precision accuracy without machining, the nylon impellers reduce assembly costs while increasing pump efficiency. Their light weight conserves driving energy. The chemical, corrosion and wear resistant qualities of the nylon material promises longer impeller life and less pump maintenance. Aico Molded Plastics can give your products new, *impelling* sales advantages, too. Discuss them with Aico now.

FREE Plastics Designer's Handbook

Shows how good design controls unit cost of molded plastics. Molded plastic parts with a low unit cost can be achieved only when the practical limitations of die-making are given full consideration when the part is being designed. Aico has prepared a Plastics Designer's Handbook that tells and illustrates how costly design errors can be avoided. A FREE copy is yours on request . . . use coupon below.

AICO'S Nook of Plastics Knowledge



INSERTS . . . may be used in plastic parts as fasteners, to support loads, simplify handling or facilitate assembly. (They may serve functional purposes or may be used purely for decoration.) Smooth rod inserts (see sample above) may be securely anchored by bending, splitting, notching, swaging or knurling. Other types of inserts are fully covered in Aico's booklet "Good Plastics Design Makes Cents." Coupon will bring your FREE copy.

aico

A completely integrated plastics molding service with unmatched experience and coordinated facilities for Engineering, Mold Building, Compression, Transfer, Plunger, Injection and Cold Molding plus the molding of Reinforced Fiberglas.

AMERICAN INSULATOR CORPORATION
New Freedom, Pa.

Please send me a FREE copy of Aico's PLASTICS DESIGNER'S HANDBOOK.

Name _____

Title _____

Company _____

Address _____

Progressive Foundry Engineering Develops Accurate Components . .

-again, UNITCASTINGS do the job *better!*

Unitcast foundry technicians, working hand-in-hand with customer's engineers, match new processes and developments with new steel casting demands.

The close tolerance requirements of this new horizontal gate mechanism proved a challenge. Designed around a new hypo-cyclic gear to reduce operating effort 80%, finished costs had to remain competitive. Each component was delivered to finished size with only touch up grinding necessary before assembly, and a high quality, durable product was marketed with the benefit of cast steel.

Unitcast offers similar service to help you with close tolerance, cost reducing problems. Write or call today for complete information.

UNITCAST CORPORATION, Toledo 9, Ohio

In Canada: CANADIAN-UNITCAST STEEL, LTD., Sherbrooke, Quebec

Unitcast

SPECIFICATION STEEL CASTINGS

formation is available from society headquarters, 33 W. 39th St., New York 18, N. Y.

Sept. 28-Oct. 1—

Association of Iron and Steel Engineers. Convention to be held at the Sherman Hotel, Chicago. Additional information is available from AISE headquarters, 1010 Empire Bldg., Pittsburgh 22, Pa.

Sept. 28-Oct. 1—

American Society of Mechanical Engineers — American Institute of Electrical Engineers. National Power Conference to be held at the Muehlebach Hotel, Kansas City, Mo. Additional information can be obtained from Meetings Dept., ASME, 29 W. 39th St., New York 18, N. Y.

Sept. 30-Oct. 1—

Institute of Radio Engineers — American Institute of Electrical Engineers. Industrial Electronics Symposium to be held at the Mellon Institute, Pittsburgh. Further information can be obtained from Robbert H. Delgado, 954 Brentview Dr., Pittsburgh 36, Pa.

Oct. 5-9—

Audio Engineering Society. Annual Convention and Professional Equipment Exhibit to be held at the Hotel New Yorker, New York. Further information is available from Harvey Associates, 580 Fifth Ave., New York 36, N. Y.

"Let us know if those wings don't hold."

Circle 428 on Page 19

Oct. 5-10—

Society of Automotive Engineers Inc. National Aeronautic Meeting, including manufacturing forum and engineering display, to be held at The Ambassador, Los Angeles. Further information is available from SAE, 485 Lexington Ave., New York 17, N. Y.

Oct. 7-9—

Gray Iron Founders' Society. Annual Meeting to be held at the Fairmont Hotel, San Francisco, Calif. Additional information can be obtained from society headquarters, National City-E. Sixth Bldg., Cleveland 14, Ohio.

Oct. 7-9—

American Vacuum Society Inc. 1959 National Symposium on Vacuum Technology to be held at the Sheraton Hotel, Philadelphia. Additional information can be obtained from society headquarters, P. O. Box 1282, Boston 9, Mass.

Oct. 8-10—

American Society of Tool Engineers. Semiannual Meeting to be held at the Chase-Park Plaza Hotels, St. Louis. Further information is available from ASTE, 10700 Puritan Ave., Detroit 38, Mich.

Oct. 11-16—

American Society for Testing Materials. Third Pacific Area National Meeting to be held at the Sheraton-Palace Hotel, San Francisco. Further information can be obtained from ASTM headquarters, 1916 Race St., Philadelphia 3, Pa.

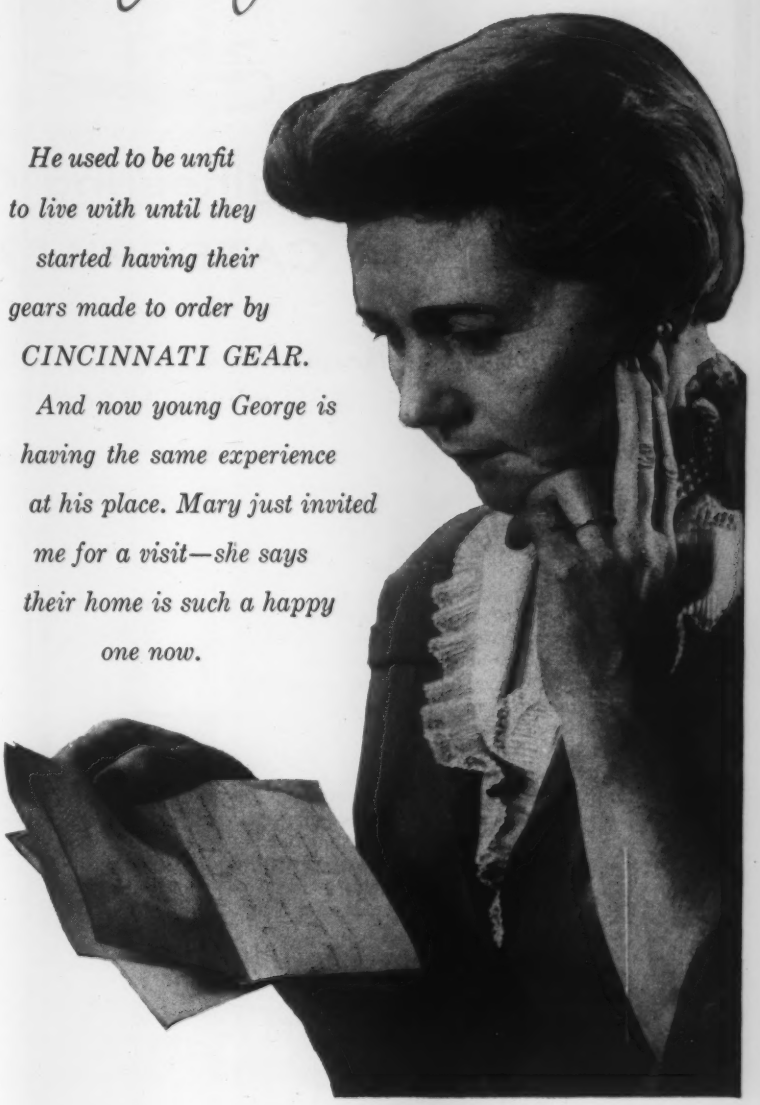
Oct. 11-16—

American Institute of Electrical Engineers. Fall General Meeting to be held at the Morrison Hotel, Chicago. Additional information can be obtained from AIEE, 33 W. 39th St., New York 18, N. Y.

Oct. 12-14—

National Electronics Conference to be held at the Hotel Sherman, Chicago. Further information is available from M. J. Jans, Conference Secretary, Armour Research Foundation, Illinois Institute of Technology, 10 W. 35th St., Chicago 16, Ill.

My George was like that...



He used to be unfit to live with until they started having their gears made to order by CINCINNATI GEAR.

And now young George is having the same experience at his place. Mary just invited me for a visit—she says their home is such a happy one now.

Guaranteed quality and reliability of product through the years have earned for us a long list of thoroughly satisfied customers. Send prints of your custom gear and gear box requirements for quotation.

CINTI®

THE CINCINNATI GEAR CO.

Wooster Pike and Mariemont Ave. Cincinnati 27, Ohio
Custom Gear Makers Since 1907

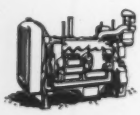
GEARS, good gears only

Circle 429 on Page 19

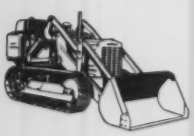
Challenging Engineering Opportunities at CATERPILLAR

be a part of the company building the world's most complete line of earthmoving equipment

Find the satisfaction of *growth* and *stability* within a *growth* company – where imaginative men are creating products for highway construction – industry – farms – national defense – products which build a better world.



Caterpillar offers top ranking Research and Development opportunities – stimulating assignments – professional and personal advancement. You'll associate with the leaders and pioneers in this field – and have at your command the finest equipment, laboratories and development facilities. Please write us, telling all about yourself. Inquiries are confidential, of course.



(Below – New Caterpillar Technical Center presently under construction)

responsible positions available in
RESEARCH — DESIGN DEVELOPMENT

GAS TURBINE LABORATORY
Design, ignition, fuel and combustion systems, etc.

ENGINE DEVELOPMENT LABORATORY
Fuel injection, turbocharged engines, combustion, etc.

VEHICLE COMPONENTS LABORATORY
New power shift transmissions, transmissions, controls, clutches, final drives.

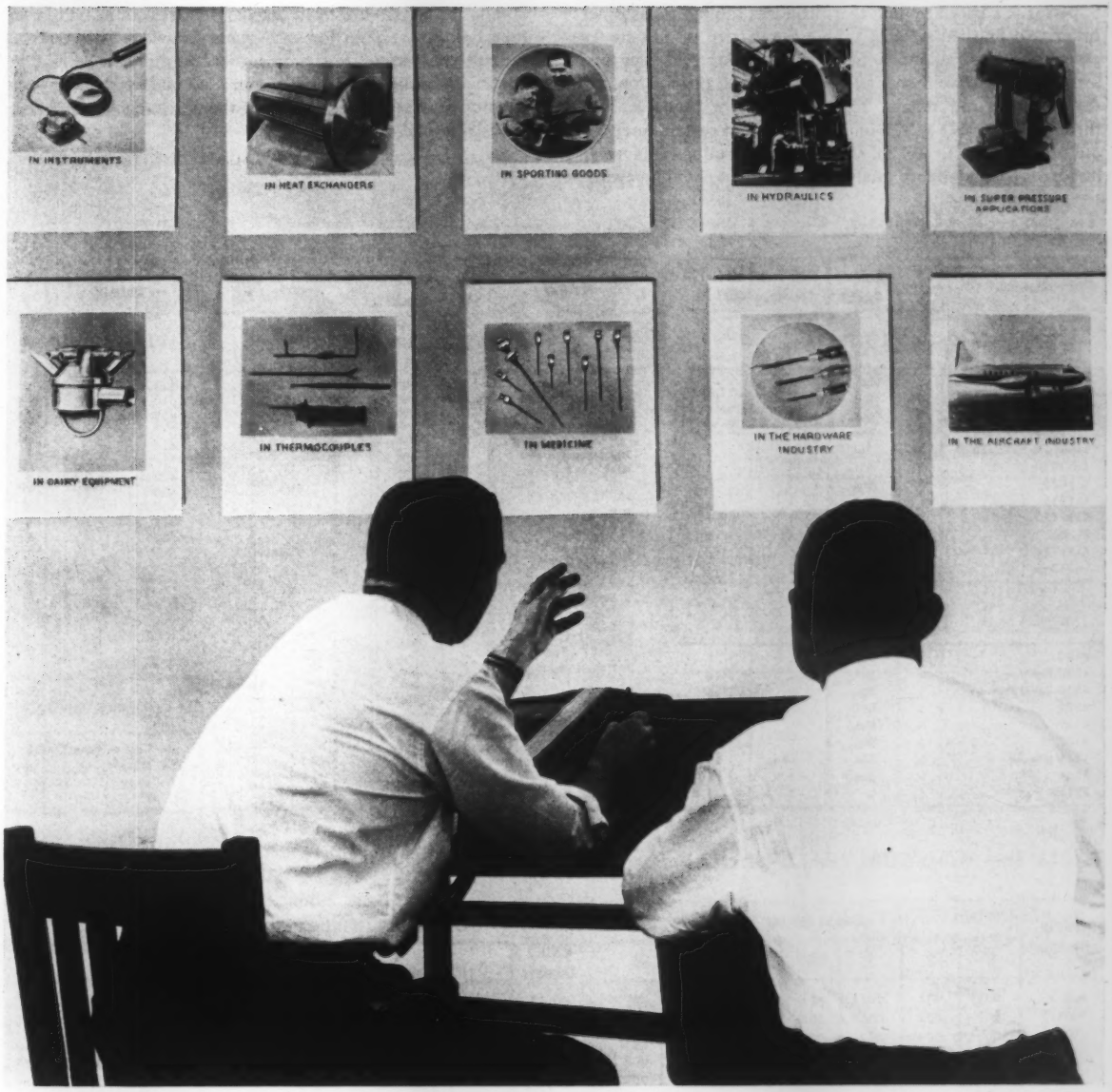
VEHICLE DEVELOPMENT LABORATORY
Quantitative and comparative performance evaluation, soil mechanics, full scale load analysis.

PRODUCT AND APPLICATION ENGINEERING DESIGN
Engines, systems, fuel injection, tractor, transmission, vehicle configuration, earthmoving machinery.

SEND RESUMÉS TO:
John A. Myers — MD-99
Professional and Technical Employment

CATERPILLAR TRACTOR CO.

PEORIA, ILLINOIS



At birth of a new design, keep Superior Tubing in mind

—to reduce weight, simplify production, cut costs

There are many reasons why this is so. Superior small-diameter tubing is a versatile product, almost unlimited in its adaptation to design requirements. Superior is the world's largest producer of this quality tubing—offers more than 120 analyses in a wide range of sizes and shapes. Superior is a specialty mill equipped to produce tubing in any shape, to any required physical and mechanical properties, to the most exacting specifications. Superior serves many industries—supplies both general and special purpose tubing for aircraft, missiles, electrical, electronic, chemical, hydraulic, dairy and nuclear applications, to name a few. The following pages are packed with data. Study them and if you have a special problem requiring more information, write us giving specific details. Superior Tube Company, 2010 Germantown Avenue, Norristown, Pa.

Superior Tube

The big name in small tubing

NORRISTOWN, PA.

All analyses .010 in. to ½ in. OD—certain analyses in light walls up to 2½ in. OD

West Coast: Pacific Tube Company, Los Angeles, California
FIRST STEEL TUBE MILL IN THE WEST

TURN THE PAGE FOR MORE DATA

Circle 431 on Page 19

SIZE LIMITS

Superior is a specialty mill that produces tubing to customer order. No finished sizes of tubing are carried in mill stocks except for accumulations of excess and for mill overruns available for developmental work, limited production, or maintenance and repair. The nominal size range is .010 through ⅜ in. OD x .125 in. wall max., but certain analyses are produced up to 2½ in. OD x .025 in. wall max. Normal limits for each standard analysis are given in detail herewith.

STANDARD MATERIALS

Standard analyses are those regularly carried in inventory as tube hollows or strip for subsequent drawing. They can be promptly fabricated to customers' orders and can be readily obtained through any one of our national warehouse distributor representatives. Many of them are regularly carried in distributors' stocks.

Note: Standard materials listed below in *black*

TABLE I—MATERIALS

Material	S W	Standard Special	Min. Wall Col. No.	Max. Wall Col. No.
CARBON STEELS				
C-1008	S	Std.	1	1
C-1008 Diesel	S	Std.	—	19
MT 1010	S	Std.	1	1
MT 1015	S	Std.	1	1
Leaded C-1015/1020	S	Std.	1	1
MT-1020	S	Std.	1	1
C-1025	S	Std.	1	1
C-1035	S	Std.	1	1
C-1045	S	Std.	1	1
E-1095	S	Std.	4	5
C-1118	S	Std.	5	6
Ingot Iron	S	Std.	1	1
ALLOY STEELS				
4130	S	Std.	1	1
4130 Bourdon	S	Std.	1	18
4130 Super Pressure	S	Std.	—	20
4132	S	Std.	1	1
4140	S	Std.	1	1
4150	S	Std.	1	1
4615 (Diesel)	S	Std.	—	19
8630	S	Std.	1	1
52100	S	Std.	1	1
STAINLESS STEELS				
303	S	Std.	2	2
304	S	Std.	2	2
	W	Std.	2	7
304 Hydraulic Quality	S	Std.	2	2
	W	Std.	2	17
304 Super Pressure	S	Std.	—	20
304L	S	Std.	2	2
	W	Std.	2	4
305	W	Std.	2	3
309	W	Std.	2	4
310	S	Std.	2	2
	W	Std.	2	4
316	S	Std.	2	2
	W	Std.	2	7
316 Super Pressure	S	Std.	—	20
316L	S	Std.	2	2
	W	Sp.	2	4
317	S	Sp.	2	2
321	S	Std.	2	2
	W	Std.	2	4
321 Hydraulic Quality	S	Std.	2	2
	W	Std.	2	18
321 Super Pressure	S	Std.	—	20
330	S	Sp.	2	2
	W	Sp.	1	4
347	S	Std.	2	2
	W	Std.	2	4
347 Hydraulic Quality	S	Std.	2	2
	W	Std.	2	18
347 Super Pressure	S	Std.	—	20
STAINLESS STEELS				
348	S W			
403 Mod. 405	S S			
410 416	S S			
420	S			
430	S			
430 Ti	W			
446	S			
502 Waspalloy	S S W			
A-286[1] 17-7PH[9]	S W			
N-155[8]	W			
16-25-6[3]	S			
19-9DL[2]	S W			
Croloy 15-15N[4]	S			
NICKEL AND				
Low Carbon Nickel[9]	S			
"A" Nickel[8]	S			
"D" Nickel[5]	S			
DURANickel[5]	S			

TABLE II—MINIMUM WALL (inches)

Outside Diameter	Column Number 1	2	3	4	5	6	7
.012	.002	.002	.0015	.002	.002	.002	—
.0312	.002	.002	.0015	.002	.005	.0025	.003
.0625	.003	.003	.002	.003	.010	.003	.004
.0937	.004	.004	.002	.004	.010	.004	.005
.125	.004	.004	.003	.004	.015	.004	.005
.1875	.005	.004	.003	.005	.020	.005	.005
.250	.005	.005	.004	.005	.020	.005	.005
.3125	.005	.005	.005	—	.028	.005	.007
.375	.005	.005	.005	—	.035	.005	.007
.4375	.007	.005	.005	—	.035	.007	.010
.500	.010	.005	.005	—	.035	.010	.010
.5625	.010	.006	.006	—	.035	.010	.012
.625	.010	.006	.006	—	.035	.010	.015
.750	.010	.006	.006	—	—	.015	.015
.875	.010	.006	.006	—	—	.015	.020
1.000	.015	.007	.007	—	—	.020	.025
1.125	.015	.008	.008	—	—	.020	.035

TABLE III—MAXIMUM WALL (inches)

Outside Diameter	COLUMN NUMBER 1 Max. Wall	2 Max. Wall	3 Max. Wall	4 Max. Wall	5 Max. Wall	6 Max. Wall	7 Max. Wall	8 Max. Wall	9 Max. Wall
.012	.004	.004	.004	.004	.004	.004	.004	.004	.004
.0312	.012	.010	.010	.010	.012	.012	.010	.010	.010
.0625	.028	.028	.015	.020	.028	.025	.020	.028	.015
.0937	.042	.042	.020	.028	.042	.035	.028	.042	.020
.125	.049	.049	.028	.035	.049	.042	.035	.049	.028
.1875	.078	.065	.035	.042	.078	.058	.049	.065	.035
.250	.095	.083	.035	.049	.095	.072	.065	.078	.035
.3125	.095	.109	.035	.049	—	.072	.065	.083	.035
.375	.125	.125	.042	.065	—	.095	.065	.125	.035
.4375	.125	.125	.042	.065	—	.095	.065	.125	—
.500	.125	.125	.049	.065	—	.109	.083	.125	—
.5625	.125	.125	.049	.065	—	.125	.083	.125	—
.625	.125	.125	.049	.065	—	.125	.083	.125	—
.750	.035	.035	.035	.035	—	—	.035	.035	—
.875	.035	.035	.035	.035	—	—	.035	.035	—
1.000	.035	.035	.035	.035	—	—	.035	.035	—
1.125	.035	.035	.035	.035	—	—	.035	.035	—

[1]Reg. U.S. Patent Office, Allegheny Ludlum Steel Corp.
[2]Reg. U.S. Patent Office, Universal Cyclops Steel Corp.
[3]Reg. U.S. Patent Office, Timken Roller Bearing Co.
[4]Patent applied for, Babcock & Wilcox Co
[5]Reg. U.S. Patent Office, International Nickel Co.
[6]Reg. U.S. Patent Office, Driver-Harris Co.
[7]Reg. U.S. Patent Office, Haynes Stellite Co.
[8]Reg. U.S. Patent Office, Union Carbide Corp.
[9]Reg. U.S. Patent Office, Armco Steel Corp.
[10]Reg. U.S. Patent Office, Western Electric

Superior Tube CO.,

SPECIAL MATERIALS

Special analyses are those for which there has been limited demand, either because of specialized use or recent development. They are not normally carried in raw material inventory, but small quantities may be available from time to time. Usually, however, raw material is procured against customer orders.

Note: Special materials listed below in *red*

HOW TO USE THE TABLES

Look for the desired analysis in Table I. Note whether the tubing is seamless or WELDRAWN* and whether the analysis is standard or special. To find the production limits, notice the lists of column numbers at the far right of Table I. These are your key to minimum and maximum wall thicknesses listed in Tables II and III. If, for example, the column number in Table I is "2" for minimum, look for the column in Table II headed by a "2."

S stands for seamless tubing W stands for WELDRAWN tubing (Welded and drawn) *T.M. Reg. in U.S. and Canada, Superior Tube Company

Material	S W	Standard Special	Min. Wall Col. No.	Max. Wall Col. No.
(continued)				
	S	Std.	2	2
	S	Sp.	2	4
	S	Std.	2	2
	S	Sp.	2	2
	S	Std.	2	2
	S	Sp.	1	1
	S	Std.	2	2
	S	Std.	2	2
	S	Std.	2	3
	S	Std.	2	2
	S	Std.	1	1
	S	Sp.	2	8
	S	Sp.	2	4
	S	Std.	2	2
	S	Sp.	2	4
	S	Sp.	2	4
	S	Sp.	2	8
	S	Sp.	2	8
	S	Sp.	2	4
	S	Sp.	2	8
NICKEL ALLOYS				
	S	Std.	3	8
	S	Std.	3	8
	S	Sp.	3	8
	S	Sp.	3	8

Material	S W	Standard Special	Min. Wall Col. No.	Max. Wall Col. No.
NICKEL AND NICKEL ALLOYS (continued)				
Monel[3]	S	Std.	3	8
	W	Std.	4	9
403 Monel[3]	S	Std.	3	8
"K" Monel[3]	S	Std.	3	8
"R" Monel[3]	S	Std.	3	8
Inconel[3]	S	Std.	3	8
Inconel "X"[3]	S	Std.	3	8
Nionel[3]	S	Sp.	3	8
Nimonic 75[3]	S	Sp.	3	8
Nimonic 80A[3]	S	Sp.	3	8
Inconel 702[3]	S	Sp.	3	8
Ni-Span "C"[3]	S	Std.	3	8
Hastelloy "C"[7]	W	Std.	2	4
Hastelloy "F"[7]	W	Sp.	2	4
Hastelloy "X"[7]	S	Sp.	2	2
	W	Sp.	2	4
Haynes 25[7]	W	Std.	2	4
Permalloy[10]	S	Sp.	4	5
Chromel "P"[15]	S	Sp.	4	5
Alumel[15]	S	Sp.	4	5
Nichrome "V"[6]	W	Std.	2	4
Invar	S	Std.	1	1
	W	Std.	2	4
COPPER BASE ALLOYS				
30% Cupro Nickel	S	Std.	3	10
Beryllium Copper	S	Std.	2	11
	W	Std.	2	12
Berylco #10[11]	S	Sp.	2	11

Material	S W	Standard Special	Min. Wall Col. No.	Max. Wall Col. No.
COPPER BASE ALLOYS (continued)				
OFHC Copper	S	Std.	4	9
Deoxidized Copper	S	Std.	4	9
Constanton	W	Std.	2	3
GLASS SEALING ALLOYS				
(446) 27% Chrome	S	Std.	2	2
42% Nickel Iron	S	Std.	1	1
	W	Std.	2	3
52% Nickel Iron	S	Std.	1	1
	W	Std.	2	3
Sylvania #4[12]	S	Std.	3	8
Rodar[13]	S	Std.	4	5
	W	Std.	2	3
Kovar[14]	S	Std.	2	11
Therlo[5]	S	Std.	4	5
REACTIVE METALS				
Unalloyed Titanium A-40	S	Std.	6	13
	W	Std.	6	14
A-55	W	Std.	6	14
Zirconium	S	Sp.	7	15
	W	Sp.	6	14
Zircaloy-2	S	Sp.	7	15
	W	Sp.	6	14
Zircaloy-3	S	Sp.	7	15

COLUMN NUMBER												
10	11	12	13	14	15	16	17	18	19		20	
Max. Wall	Max. Wall	Max. Wall	Max. Wall	Max. Wall	Max. Wall	Max. Wall	Max. Wall	Max. Wall	Max. Wall	Min. ID	Max. Wall	Min. ID
.004	.004	.004	.004	.004	—	.004	.004	.004	—	.003	—	.003
.012	.012	.012	.010	.010	.0125	.012	.010	.010	—	.004	—	.004
.020	.025	.015	.015	.015	.020	.028	.020	.020	—	.006	—	.006
.028	.032	.020	.020	.020	.028	.042	.028	.028	—	.010	—	.010
.035	.035	.025	.032	.025	.035	.049	.035	.035	.053	.015	.053	.015
.042	.049	.032	.035	.032	.049	.078	.042	.035	.083	.020	.083	.020
.042	.065	.042	.049	.035	.058	.095	.049	.049	.110	.030	.110	.030
.042	.072	.042	.065	.042	.065	.095	.049	.049	.134	.045	.134	.045
.042	.083	.049	.083	.049	.083	.125	.058	.049	.141	.093	.141	.093
.042	.095	.049	.095	.049	.083	.125	.058	.049	.156	.125	.156	.125
.042	.125	.065	.109	.065	.095	.125	.065	.049	.172	.156	.172	.156
—	.125	.065	.125	.065	.095	.125	.065	.049	.187	.1875	.187	1.875
—	.125	.065	.125	.065	.125	.125	.065	.049	.218	.1875	.218	1.875
—	.095	.049	.035	.035	.125	.095	.035	.035	—	—	.218	3.125
—	.083	.049	.035	.035	.125	.095	.035	.035	—	—	—	—
—	.083	.065	.035	.035	.125	.095	.035	.035	—	—	—	—
—	.083	.065	.035	.035	.125	.095	.035	.035	—	—	—	—

LARGE DIAMETER THIN-WALL TUBING

SEAMLESS

Material	OD	Min. Wall	Max. Wall
304	1¼	.010	.035
321	1½	.010	.025
Monel	2⅛	.010	.025
347	2½	.010	.025

WELDRAWN

Material	OD	Min. Wall	Max. Wall
304	1¼	.010	.035
321	1½	.010	.025
347	2⅛	.010	.025
	2½	.010	.025

[11]Reg. U.S. Patent Office, Beryllium Corp.
[12]Reg. U.S. Patent Office, Sylvania Electric Prod.
[13]Reg. U.S. Patent Office, Wilbur B. Driver Co.
[14]Stocked and sold through the Stupakoff Div. of the Carborundum Co., Latrobe, Pa., TM Reg. U.S. Patent Office, Westinghouse Electric Corp.
[15]Reg. U.S. Patent Office, Hoskins Mfg. Co.

2010 GERMANTOWN AVE., NORRISTOWN, PA.

Circle 431 on Page 19

SUPERIOR SPECIALTY PRODUCTS

HYPOFLEX® HYPODERMIC NEEDLE TUBING

Made in Type 304 in gages 6 through 33 in 28 standard sizes. Lengths to 12 ft. max., all to extremely close tolerances. Close quality control assures bright, clean surfaces. Widely used in other than hard-drawn temper for a host of mechanical applications.

CAPILLARY TUBING

Made in Types 304, 316, 321, 347, 446, C-1008, nickel, Monel, Inconel and others. Uniformly bright, lustrous, scalefree outer and inner surfaces. Sizes up to 3/16 in. OD. IDs range from .004 in. min. to .040 in. max. Coil lengths up to 3000 ft. max.

SUPER PRESSURE TUBING

For pressures up to 100,000 psi. Normally produced from Types 304, 316, 321, 347 and 4130 alloy steel. Available in single wall or in composite wall for extreme pressures in either the annealed or 1/8 hard tempers. Sizes from 1/8 through 3/4 in. OD in lengths up to 30 ft. Every length hydrostatically tested up to 20,000 psi, plus complete laboratory inspection.

AIRCRAFT HYDRAULIC TUBING

Made in Types 304, 321 and 347 to rigid MIL-T and AMS specifications. Each length 100% hydrostatic and flare tested. Guaranteed smooth and clean external and internal surfaces. All tubing furnished with certified test reports. Available in both seamless and WELDRAWN forms in sizes ranging from 3/16 through 1 1/8 in. OD. Every length clearly marked with our name, specification, analysis, heat number and size.

MINIATURE HEAT EXCHANGER TUBING

Made from Types 304, 304L, 310, 316, 316L, 321 and 347 stainless steels. Strict adherence to the highest commercial and military combined specifications. Size ranges from 1/8 in. OD x .003 in. wall min. to 1/4 in. OD x .016 in. wall max. Completely quality controlled with wall uniformity and extra-close tolerances paramount. Precise surface inspection. Has desirable brazing and welding qualities.

SUPER ALLOY TUBING

For extra strength at high temperatures. A minimum of 1000-hr. stress rupture strength of 25,000 psi at 1200°F. Resists progressive scaling and other types of corrosion. Analyses include Types 316, A-286, 19-9DL, 16-25-6, Croloy 15-15N, Inconel X, Hastelloy C, Inconel 702, Nimonic 80A, Hastelloy X, Hastelloy F, Waspalloy, Haynes 25, and N-155. Will not fail through brittle fracture or show excessive grain growth at operating temperature.

DIESEL FUEL INJECTION TUBING

For high and low-pressure applications. Made from Types C-1008, MT-1010 and 4615 alloy steel. ID surfaces given special conditioning. ID free from radial cracks. Supplied in annealed condition for easy fabrication. Sizes from .012 through 5/8 in. OD max., .003 through 3/16 in. ID min.

CARBON MECHANICAL TUBING

11 standard and 3 special grades. Stocked by leading warehouse distributor representatives in U.S. and Canada. Broad range of sizes with diverse mechanical and physical properties. Available on 50-ft. minimum order in random cut or multiple lengths.

(SAE) CARBON HYDRAULIC TUBING

Bright, clean, tested. Made from nonaging steel, offers high ductility properties. Produced to SAE, JIC, AMS and ASTM specifications. Sizes from 1/8 through 1 1/8 in. max. Every length 100% hydrostatic pressure and flare tested. OD and ID surfaces protected with a special rust preventive.

TOOL STEEL TUBING

Produced from MT-1095 high-carbon steel and E-52100 alloy steel. Both grades excel in strength, hardness and wear resistance. Can be oil hardened to improve toughness and abrasion resistance. Available in sizes .012 through 5/8 in. max. to close tolerances.

BOURDON TUBING

Controlled characteristics in many special shapes. A wide variety of materials, including 304, 316, beryllium copper, K Monel, Ni-Span C, Inconel X, 4130 alloy steel. Selected raw material, ID conditioned stock. Offers good creep resistance, low hysteresis, nonrelaxation, excellent fatigue life. Produced in any shape: oval, elliptical, flat oval, etc.

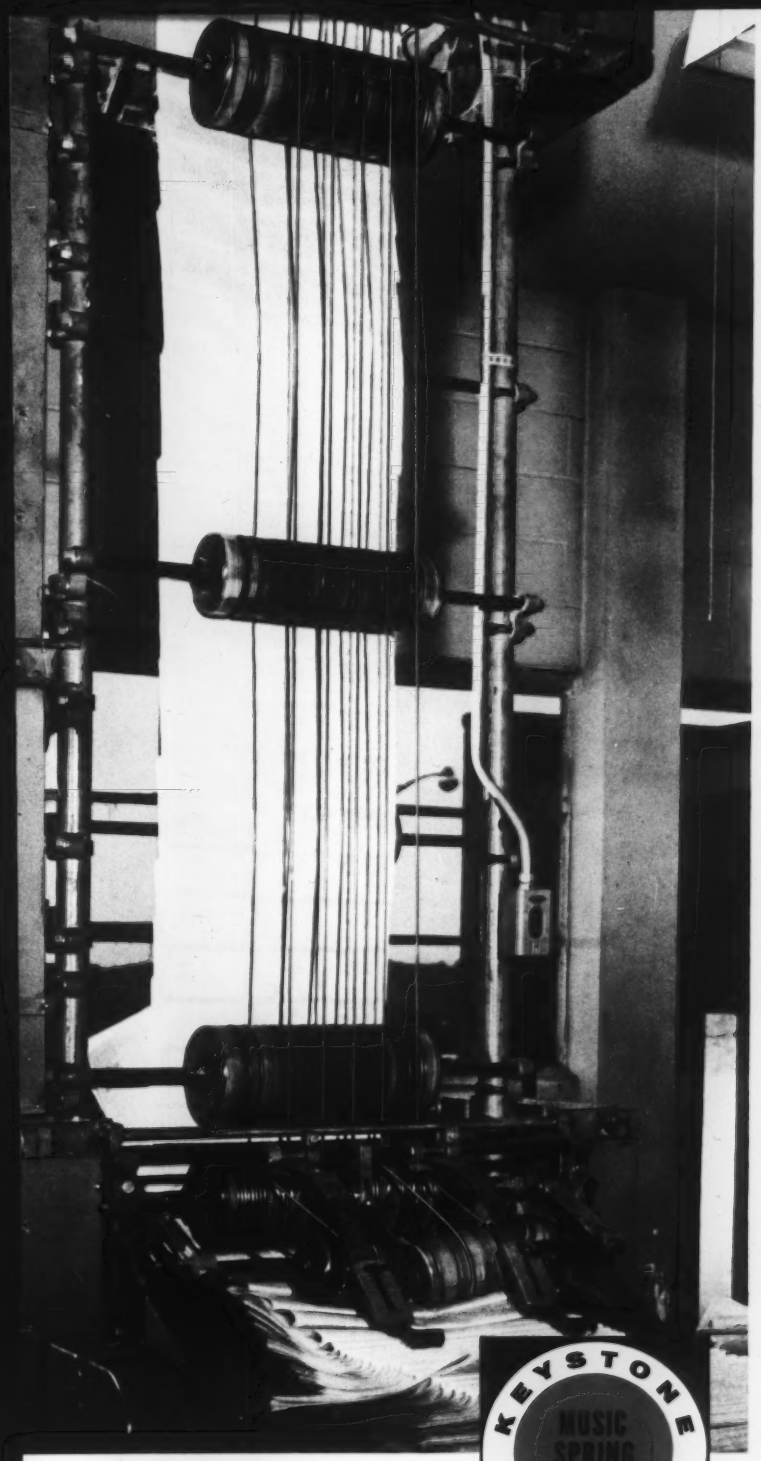
TUBING FOR THERMOCOUPLES

For temperature extremes. Available in many materials, including constantan, Chromel P, Alumel, ingot iron, Inconel, Inconel X, low-carbon nickel, Nichrome V, 305, 310. Excellent fabrication characteristics. Operating temperatures may go as high as 2150°F, depending on material. Most of these materials possess high thermal EMF against platinum. Size range up to 5/8 in. OD.

SUPERIOR TUBE CO., 2010 Germantown Ave., Norristown, Pa.

Circle 431 on Page 19

Circle 433 on Page 19→



CARRYING THE NEWS on a

CUTLER-HAMMER CONTROL C-H

wire belt

Keystone Music Spring Wire used in Cutler-Hammer newspaper conveyors delivers newspapers from the presses on time, all the time.

Folded newspapers—varying from a few pages to extra thick editions ride directly from the high-speed press, between endless coiled wire belts made from specially processed Keystone Music Spring Wire. The papers are lifted straight up, carried overhead and conveyed to the delivery room. The flexibility in the design of the Cutler-Hammer conveyor with its coiled springs permits turns and bends as required by the installation.

Failure of a single spring could mean a deadline missed. It is for this reason that Cutler-Hammer uses Keystone Music Spring Wire—a wire that creates owner satisfaction.

Despite comparatively severe and small radius bends required to form the belts, Keystone Music Spring Wire runs smoothly and flawlessly through the forming machines at Cutler-Hammer.

Keystone Music Spring Wire is successfully used in many other applications requiring high quality, high strength and extreme fatigue resistance.

This same kind of production advantage and customer acceptance can be of value to you and your product. It only takes a telephone call to your Keystone representative to learn the details.

Keystone Steel & Wire Company, Peoria 7, Illinois

This battery of Cutler-Hammer newspaper conveyors was recently installed at the modern plant of the Peoria Journal Star, Peoria, Ill.

KEYSTONE

WIRE FOR INDUSTRY

TRABON®

CENTRALIZED LUBRICATING SYSTEMS

Verson Press

Trouble around the corner? Trabon warns you!

First with **Centralized Warning** — Trabon gives you a **truly centralized** oil or grease system. Blocked bearings located "around the corner" or out-of-sight, telegraph "trouble" to the pump or control station. (And inexpensive Reset Indicators pinpoint the blockage.)

Why take chances with your expensive machinery investment? A fool-proof Trabon System of modern design makes sure that every bearing gets a positive, measured shot of lubricant at correct intervals. Your machine will stay on the job producing parts — and profits — for you. And you will also notice a corresponding decrease in power costs, repair costs and lubricant costs. Lubrication is done efficiently, economically **and positively.**

Ask your Trabon representative for a free lubrication survey of your plant.
You will be amazed at how many ways Trabon can save you money.

"Centralized" OIL AND GREASE SYSTEMS "Meterflo" CIRCULATING OIL SYSTEMS

Trabon® **Trabon Engineering Corporation** 28769 Aurora Road • Solon, Ohio

CASE HISTORIES FROM MT. VERNON FILES

University makes 3 speakers from 1 Mt. Vernon die casting

The advent of stereo has brought about a demand for smaller cabinets and posed a problem for speaker engineers: design a small moderately priced unit capable of sound reproduction as good as that of present day speaker systems 3 to 4 times its size.

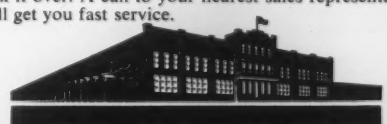
University engineers came up with 3 answers—3 new 8 inch speakers with outstanding performance characteristics—made of highest quality materials, with a better finish than ever...all at greatest possible economy thanks to the use of Mt. Vernon Die Castings.

This zinc pressure die cast "basket" provides a universal 8" frame for three different speakers: 1—a full range 3 way diffaxial, 2—a standard woofer, and 3—a new type high compliance woofer. This single part, formerly made of several stampings, contains the supports, flanges, slots, ribs, holes, studs and channels for all three models. It possesses all the rigidity and dimensional stability needed to assure permanent centering of the speaker cone, voice coil and magnetic element at increased power ratings.

Designed to very close tolerances, the castings are dependably uniform from speaker to speaker. They offer better design, greater rigidity and reliability than the assembled stamped basket at no increase in cost. Best of all, final speaker assembly is speeded up with fewer steps, resulting in greater economies, enabling University to offset steadily increasing general production costs. The finished products have a superior quality look that matches their superlative performance.

Back and front the casting is intricate, and the die even more so. However, Mt. Vernon's complete fourfold service takes these complex casting assignments in stride, gives service that more than satisfies...service that keeps customers happy for years and years...in the case of University Loudspeakers, Inc., of White Plains, N. Y....for over 15 years.

If you too would like to switch to die castings, let's talk it over. A call to your nearest sales representative will get you fast service.

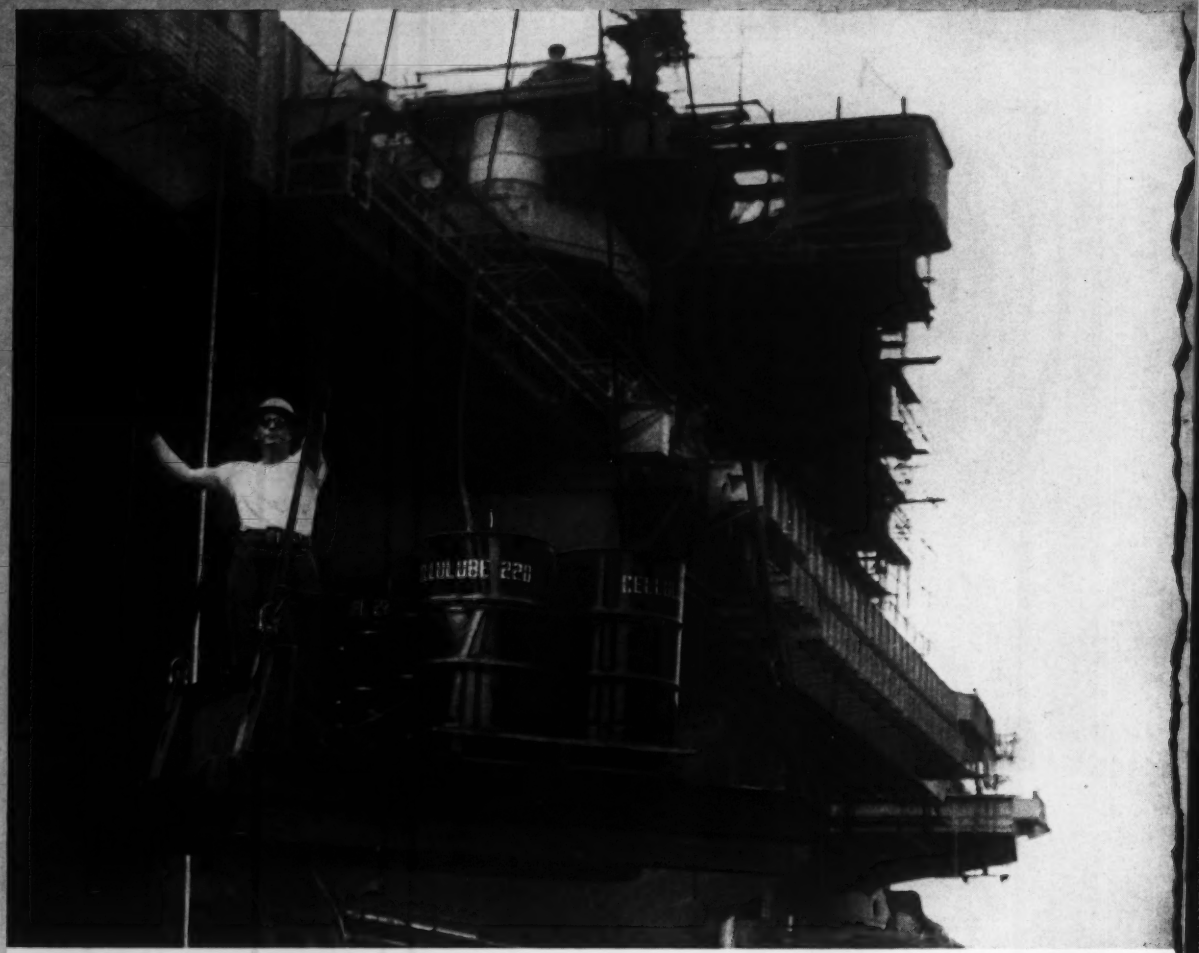


MT. VERNON
DIE CASTING CORP.
STAMFORD CONNECTICUT

DIE CASTING RESEARCH FOUNDATION PARTICIPANT

SALES REPRESENTATIVES

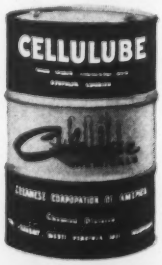
BALTIMORE, MD.: Mr. C. M. Gordan, 919 St. Paul St.
BROOKLYN, N. Y.: Mr. Robert V. Moore, 2317 Plumb 2nd St.
CLEVELAND, OHIO: Mr. Grant Eller, 6 East 194th St.
GUILDERLAND, N. Y.: Mr. David H. King, 75 Willow St.
PITTSBURGH, PA.: Mr. Andrew W. Anderson, 300 Pasadena Drive So.
QUINCY, MASS.: Mr. Edmund W. Libby, 91 Merrymount Rd.
ROCHESTER, N. Y.: Mr. William Sauers, 101 Briarcliff Rd.
SKANEATELES, N. Y.: Mr. Jerome J. Theobald, 9 E. Genesee St.
STAMFORD, CONN.: Mr. Anker Anderson, Cascade Road
VALLEY FORGE, PA.: Mr. G. T. McMaster, P.O. Box 115



Cellulubes by Celanese shoulder the big jobs . . .

In standard tests, Cellulubes were dripped and flooded onto molten metal at 1500° F without igniting! In a standard flammability test, Cellulubes were sprayed under pressure onto burning oil-soaked cotton waste; they actually extinguished the fire on a portion of the flaming material!

No wonder Cellulubes made by the Celanese Corporation of America are specified for big jobs in hydraulics which present potential fire hazards.



FM

Factory Mutual-Approved
(Cellulubes 150 and 220)

CELANESE CORPORATION OF AMERICA, CHEMICAL DIVISION
DEPT. 565S, 180 MADISON AVENUE, NEW YORK 16, N. Y.

Please send me:

☐ Technical bulletin ☐ Sample of _____ viscosity.

Name _____ Title _____

Company _____

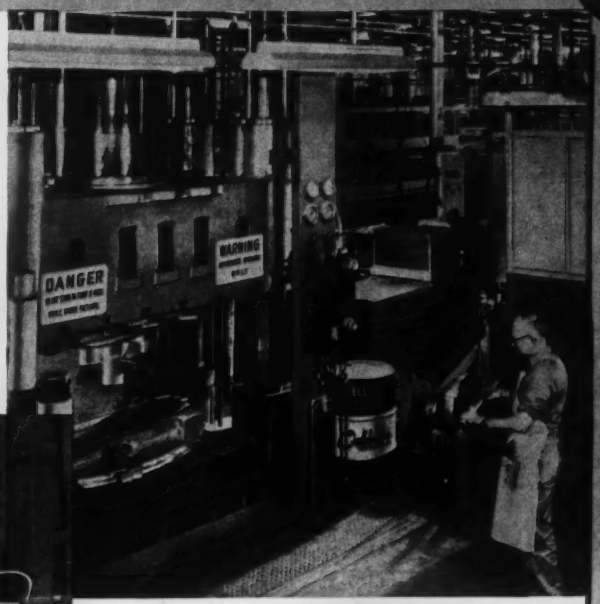
Address _____

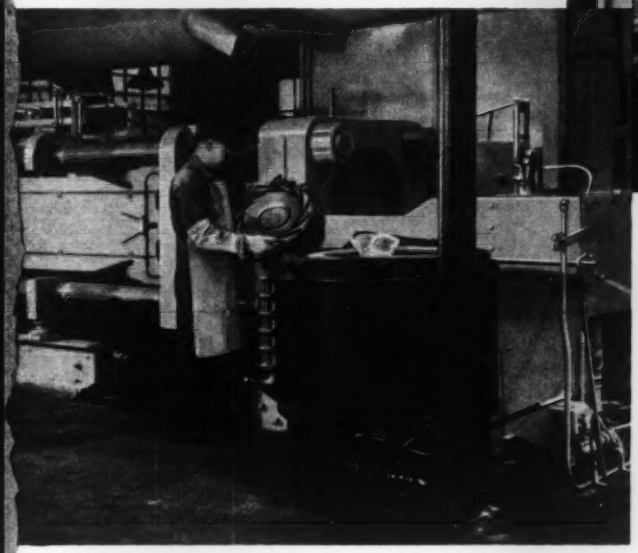
City _____ Zone _____ State _____

Application I have in mind _____

U.S.S. INDEPENDENCE, the Navy's newest 60,000-ton supercarrier, takes on 55-gallon drums of Cellulube, part of a six-car trainload. Used to operate giant aircraft elevators, Cellulubes overcome the hazard of fire and explosion. Cellulubes are used in the combat fleet for fire-safe hydraulic duty.

TITANIUM PARTS expanded by heating to 1000°F are transferred from an electric furnace to a powerful hydraulic press. North American Aviation uses fire-resistant Cellulube 220 to protect against the dangers of line fracture or leakage during this form-die quenching operation for making high-strength aircraft parts.





DIE-CASTING MACHINES at Alcoa's Garwood plant are hydraulically actuated. Furnace in foreground shows the proximity of the lines to the molten metal. Lines operate at pressures up to 3500 psi. Cellulube hydraulic fluids minimize the danger of fire.

reduce fire hazards near hydraulic machines

Wherever hydraulic lines pass near a source of ignition, fire-resistant Cellulubes are a must.

The fluids are available in six ranges of viscosity, and they maintain these viscosities under the severest conditions of mechanical shear. Cellulubes display excellent physical and chemical stability. They do not foam, cannot drop additives into the system. In fact, they actually have a cleansing action in machinery. Low compressibility insures efficient power transfer. The good lubricant properties of Cellulubes safeguard equipment life and decrease maintenance.

Let us help you with your hydraulic problems wherever a hazard might exist. Celanese, pioneer in fire-resistant functional fluids, can draw on long field experience and research background in solving your problem. For full technical specifications, send for the "Cellulube Safety Series" manual. If you'd like a sample of Cellulube, please let us know what application you have in mind.

Celanese Corporation of America, Chemical Division, 180 Madison Ave., New York 16, N. Y.

Celanese® Cellulube®

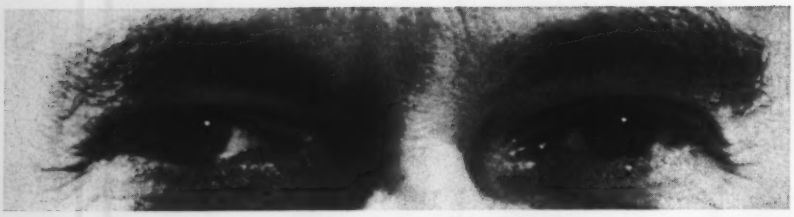
Cellulubes... Celanese CHEMICALS fire-resistant functional fluids

In Canada: Canadian Chemical Company Limited, 2035 Guy St., Montreal, Toronto, Vancouver • Export Sales: Amcel Co., Inc., and Pan Amcel Co. Inc., 180 Madison Ave., New York 16

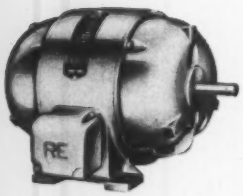
Circle 437 on Page 19

CELANESE CELLULUBES

WHO BUT REULAND WOULD OFFER AN



HONOR SYSTEM MOTOR SERVICE POLICY?



15-Year-Old Service Policy Takes the Word Of Any Local Electric Motor Service Shop of Your Choice

Here is another indication of Reuland quality... and the extent to which our company stands behind its products. It is based on a trust in people, and a trust in Reuland workmanship. It has met the test of time, and captured the acclaim of Original Equipment Manufacturers... and *their* customers.

Whether *your* company is an O.E.M., or a User, the Reuland Honor System Service Policy can be your passport to uninterrupted machine operation. If you are tired of delays while service responsibility is determined... if you would like to talk to a motor company that can look you straight in the eye and be measured, your experience with Reuland could be a revelation.

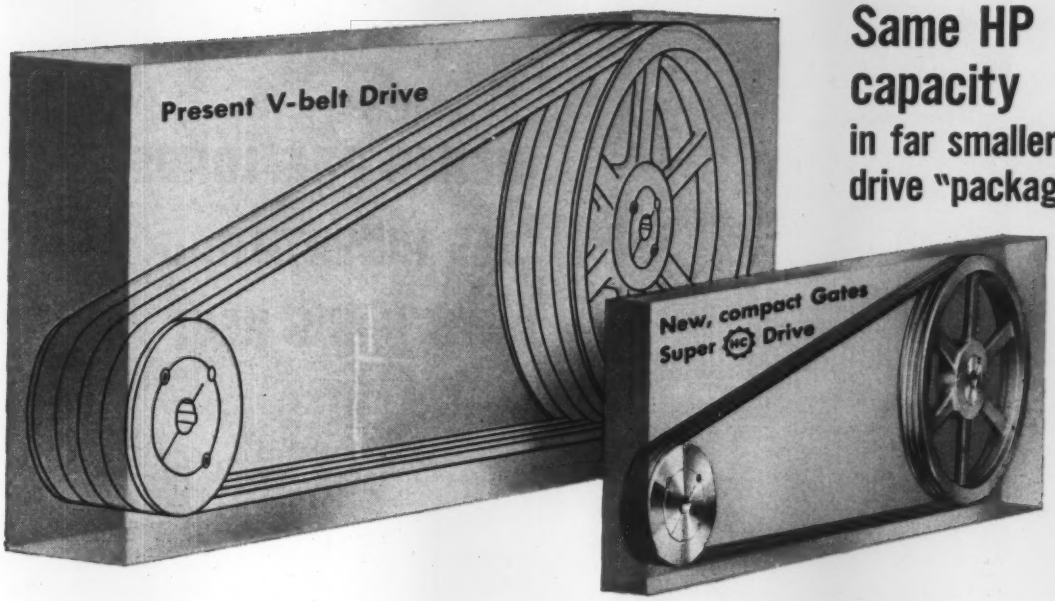
A free copy is available on request. Explains the simple steps to take. Shows how Reuland's unique philosophy of doing business permits it to offer the industry's only Honor System Service Policy! All company officials should have a copy. We'll mail yours promptly.

MODERN POWER FOR MODERN DAY PRODUCTS
...all in lightweight aluminum frames!

REULAND MOTORS RE®

REULAND ELECTRIC COMPANY
WESTERN DIVISION: *Alhambra, California*
EASTERN DIVISION: *Howell, Michigan*
Distributors in all Principal Cities

For important Reuland Engineering data refer to Sweet's 1959 Product Design File, section 5a



Same HP capacity in far smaller drive "package"

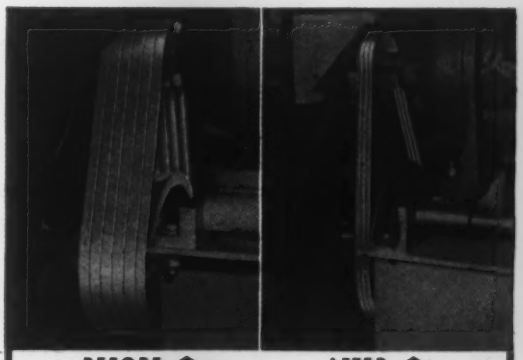
New high capacity V-belt cuts drive cost as much as 20%

Reduce size, cut costs! Gates new Super HC V-Belt Drive puts power transmission in a smaller package—cuts costs all along the line!

With Gates Super HC V-Belt Drives you use fewer belts, smaller sheaves. Sheave diameters and widths are reduced 30% to 50%; center distances 20% and more; weight is substantially reduced. *Initial drive cost is cut as much as 20%.*

Furthermore, as every designer knows, a more compact drive insures other savings, too. Smaller housings, bearings, bases and other components cost less; machining time is often reduced; shipping costs are lowered. And finally, the ultimate user gets the benefit of lower *maintenance* costs—less down time!

"The Modern Way to Design Multiple V-Belt Drives" is an informative handbook on Gates major advance in power transmission—the Super HC V-Belt Drive. Your nearby Gates Distributor—listed under Belts or Belting in your phone book Yellow Pages—will be glad to furnish a copy of this handbook.



BEFORE ◆ AFTER ◆

COMPARE: Conventional drive at left was replaced with Gates new Super HC V-Belt Drive at right. Three of Gates new, narrow HC V-Belts do the work of the former 6 standard width belts. In this application the new drive actually takes *one-third* the space of old!

TPA 391

Gates

World's Largest Maker of V-Belts

The Gates Rubber Company • Denver, Colorado
Gates Rubber of Canada Ltd., Brantford, Ontario

Gates Super HC V-Belt Drives

HIGHER PRE-LOADS . . . LESS INDENTATION WITH H-K'S NEW 1960 SERIES FORGED SOCKET HEAD CAP SCREWS

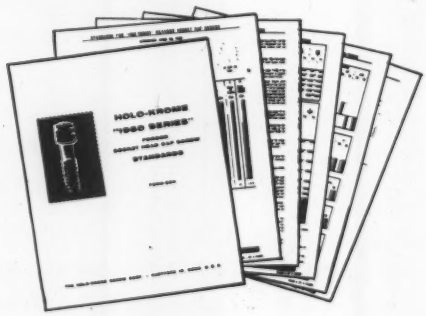
- LOAD DISTRIBUTED OVER WIDER BEARING SURFACE
- HIGHER PRE-LOADS
- INDENTATION UNDER HEAD ELIMINATED
- SMALLER, FEWER FASTENERS REQUIRED
- INCREASED VIBRATION RESISTANCE
- ENLARGED SOCKET IN MANY SIZES
- NO INCREASE IN PRICE

HOLO-KROME SOCKET SCREWS

THE HOLO-KROME SCREW CORPORATION • HARTFORD 10, CONN.

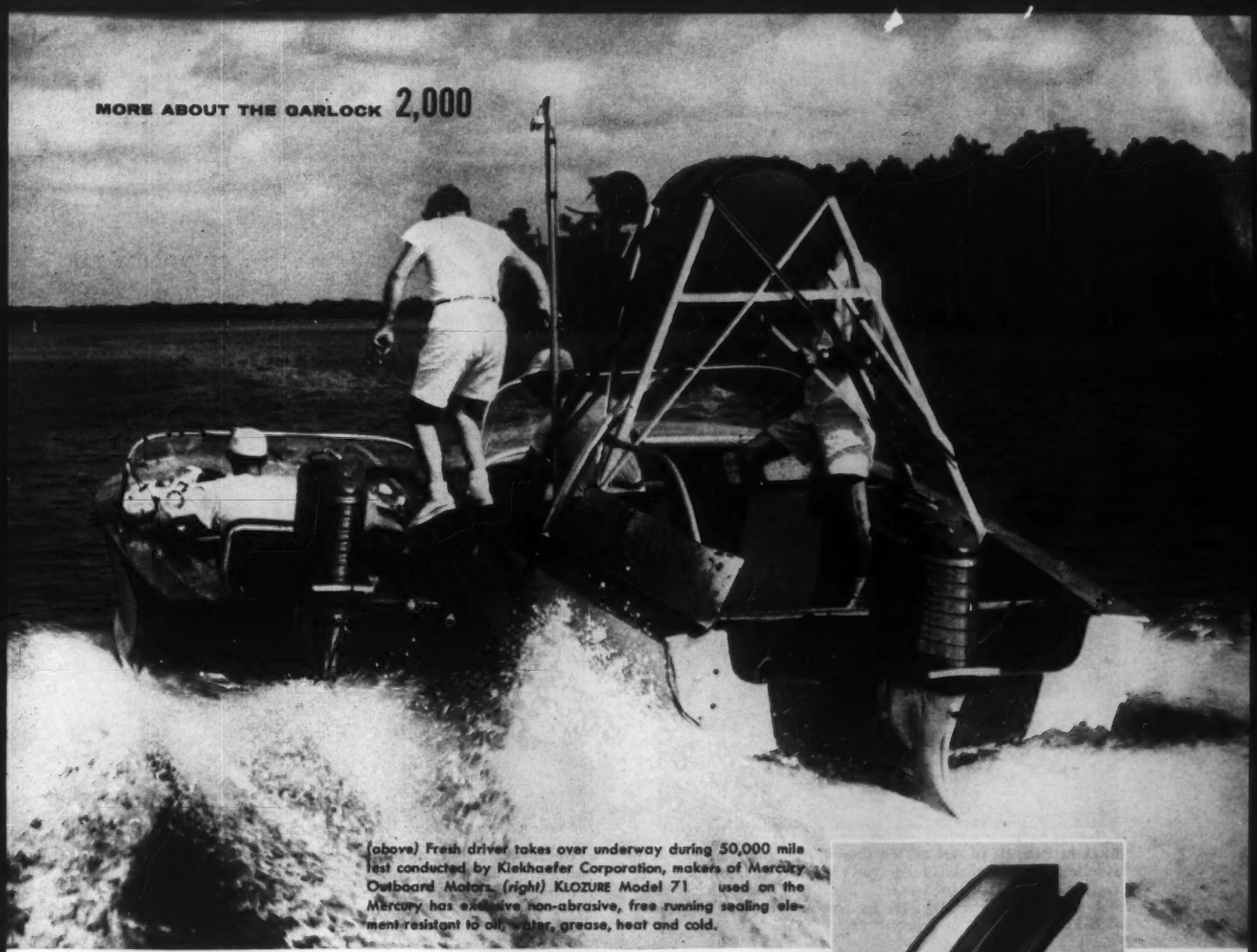
SOLD ONLY THROUGH AUTHORIZED DISTRIBUTORS

Send for your FREE copy of H-K's complete dimensional standard for the new 1960 SERIES. Ask for Form CSN.

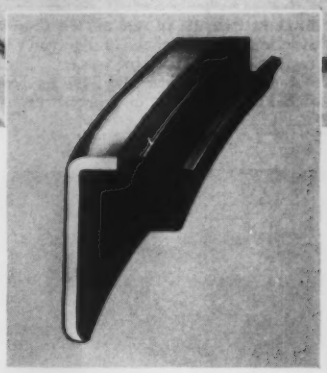


Circle 440 on Page 19

MORE ABOUT THE GARLOCK **2,000**



(above) Fresh driver takes over underway during 50,000 mile test conducted by Kiekhaefer Corporation, makers of Mercury Outboard Motors. (right) KLOZURE Model 71 used on the Mercury has exclusive non-abrasive, free running sealing element resistant to oil, water, grease, heat and cold.



50,000 MILE OUTBOARD TEST

PROVES ENDURANCE OF GARLOCK KLOZURE* *OIL SEALS, TOO!*

In a fantastic non-stop endurance run equal to 20 years of average family outboarding, Garlock KLOZURE Oil Seals maintained positive sealing against grease and water without sign of physical wear or deterioration. Applied on the steering swivel shaft of two Mercury Mark 75E outboards, KLOZURES worked 'round the clock for 68 straight days keeping grease in the bearings. Hard knocks from rough water, floating obstacles, and foreign matter picked up at surface speeds averaging 30 miles per hour, could not injure the KLOZURES.

What better proof is there of long life and dependability! Garlock KLOZURE Oil Seals are compact, easy to install, and are available from one of the largest stocks of standard sizes for shafts from 1/8" to 44". Whether it's in boating or industry, specify Garlock for the most effective seal on the market.

KLOZURES are another of the Garlock 2,000 . . . two thousand different types of packings, gaskets, and seals. The only complete line. It's one reason you get unbiased recommendations from your Garlock representative. Call him or write for KLOZURE Catalog 20.

*Registered Trade Mark

GARLOCK

Packings, Gaskets, Oil Seals, Mechanical Seals, Molded and Extruded Rubber, Plastic Products

THE GARLOCK PACKING COMPANY, Palmyra, N. Y.

For Prompt Service, contact one of our 26 sales offices and warehouses throughout the U.S. and Canada.

Circle 441 on Page 19

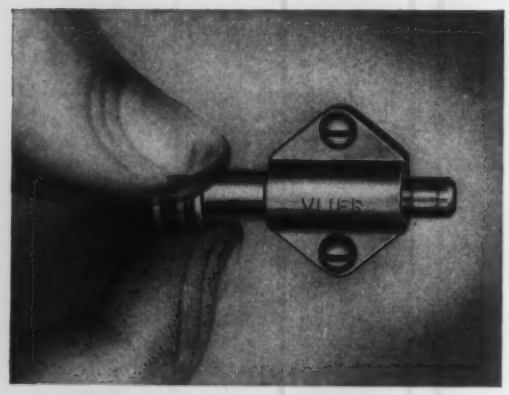
Practical Design Tips

No. 4 of a series

Hundreds of companies are now saving by using off-the-shelf Vlier products like the ones shown below. These simple, low cost, precision parts save designers time and, in many cases, simplify product design and manufacture. Why not investigate their possibilities today.

BALL PLUNGERS WORK BETTER than spring plungers when side loads are involved. Balls won't bind from side thrusts, retract easily. Available in new, "Mini-ball" sizes, down to #4-48x3/16"; standard sizes from #10-32x1/2" to 5/8-11x1". Various end pressures.

TORQUE-LIMITING WRENCH for assembling small parts, adjusting set screws, etc., is easily made from a Vlier Torque Handle and a length of hexagon stock. Prevents over-tightening, and subsequent damage to parts. End pressure is adjustable from 15 to 200 lbs.

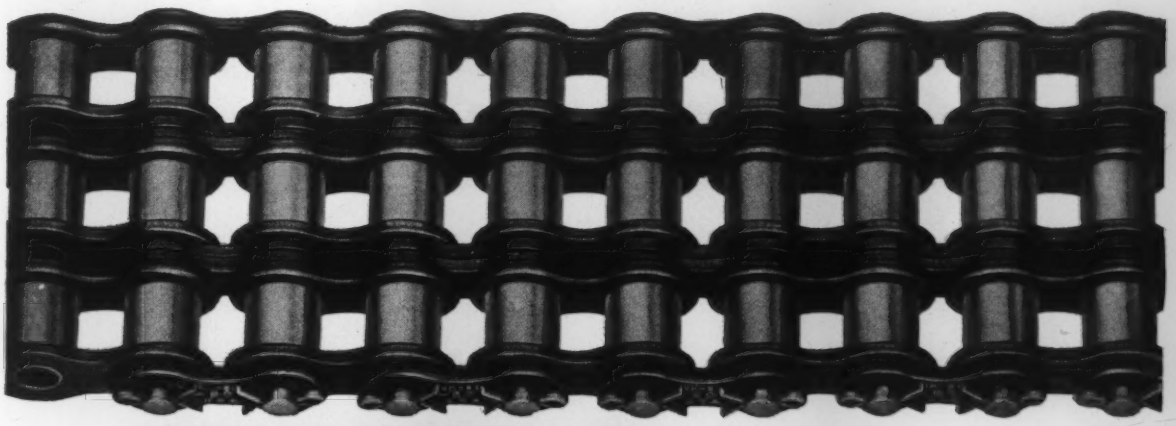


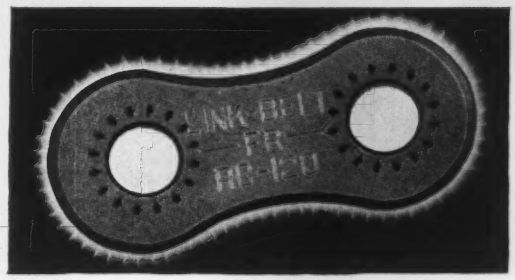
NEED A SMALL, LIGHTWEIGHT, SPRING-LOADED LATCH? One enterprising designer modified a standard Vlier S-88 Spring Stop that did the job perfectly. Entire latch weighs less than 1/3 oz. Body is die-cast aluminum; plunger is heat-treated alloy steel. Various plunger pressures. Available on quantity orders only.

FREE IDEA BOOKLET. Illustrations in this 16-page booklet show how others have profited from the use of Vlier products. Illustrates both the usual and unusual applications. May suggest ways *you* can save. Write for your copy today.

VLIER
Engineering Corporation
A subsidiary of Barry Controls, Inc.
8900 Santa Monica Blvd. • Los Angeles 46, California

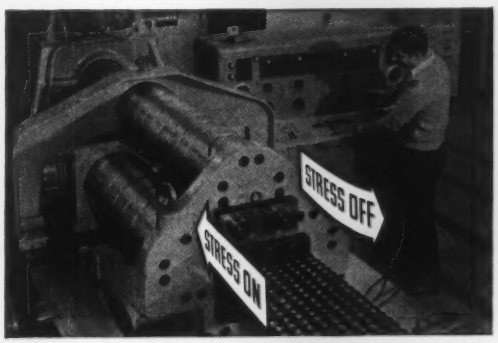
Circle 442 on Page 19





Arrows indicate critical areas treated with compressive stresses to improve fatigue resistance.

Fortified against fatigue



65 TONS OF CYCLIC TENSION! With this equipment—largest of its kind known to be in operation in roller chain testing—Link-Belt tests and rates roller chains. Rapid "stress-on, stress-off" action duplicates operating conditions at a greatly accelerated pace . . . proving over and over that Link-Belt chains are fortified against fatigue.

Link-Belt offers special FR® processed roller chain for applications involving repeated high-tensile loads

Jobs too rugged for standard roller chains are taken in stride by Link-Belt FR roller chain. Through its patented FR process, Link-Belt gives *greater dynamic strength* to the larger sizes of chain most likely to encounter severe cyclic loading. FR greatly raises the chain's endurance limit by compressing metal around pitch holes—the critical sidebar areas most vulnerable to fatigue failure.

The FR process results from the same design and metallurgical research that has produced many more "extras", all *standard* in Link-Belt roller chains. They include shot-peened rollers, close heat-treat control, lock-type bushings and others. For further details on Link-Belt roller chains, send for Book 2657.

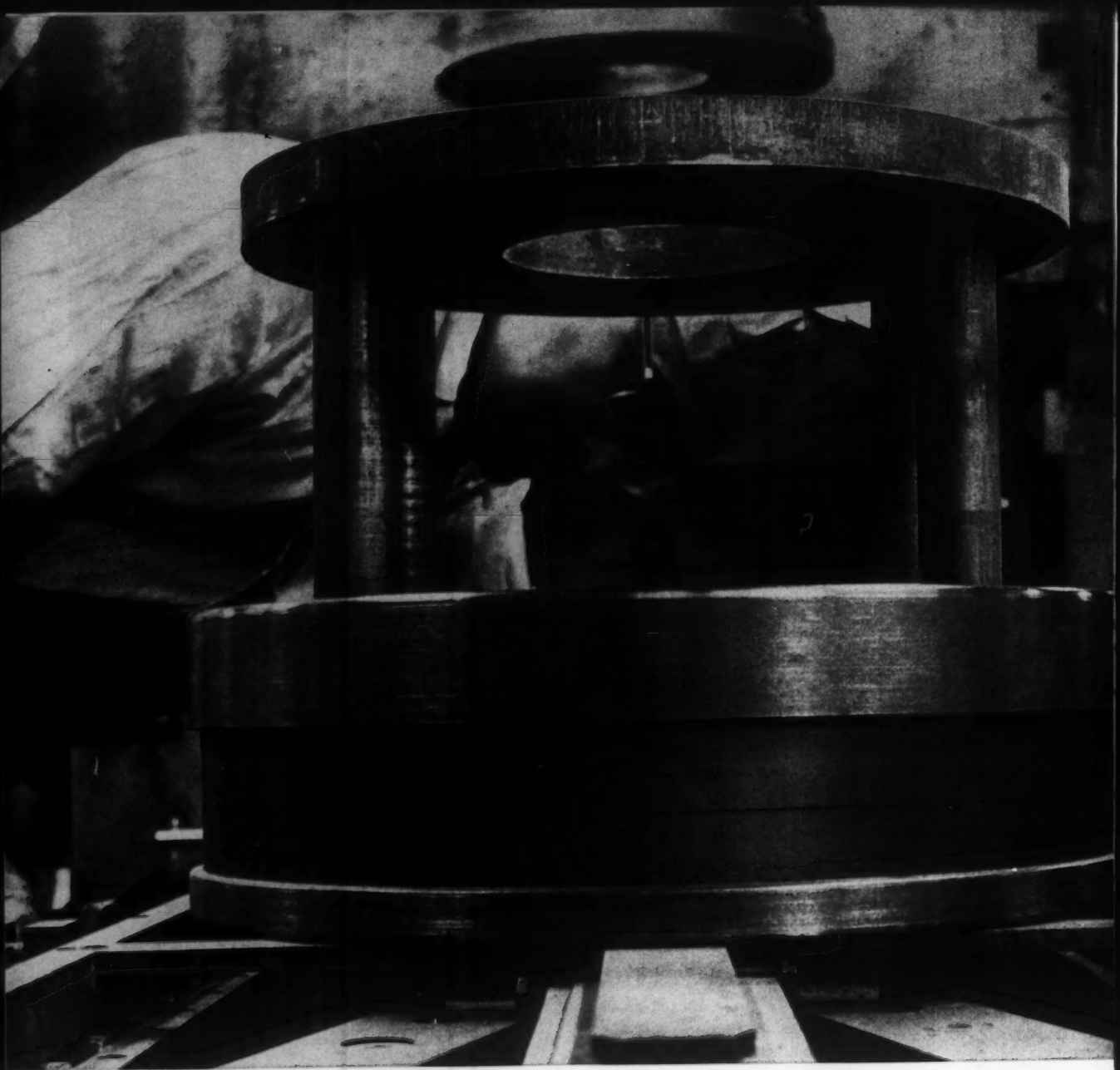
LINK-BELT

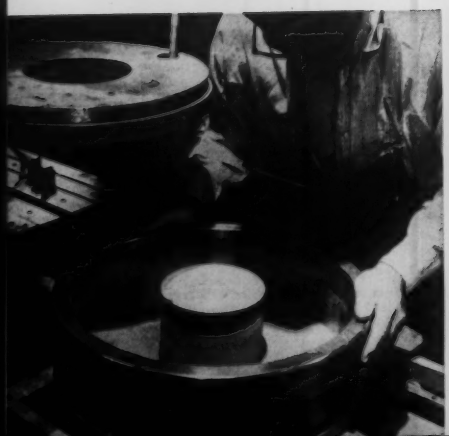
15,080

ROLLER CHAINS AND SPROCKETS

BOOK 2657 has 154 pages of roller chain data. For your copy, contact your nearest Link-Belt office. (See CHAINS in the yellow pages of your phone book.)

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World.





Here's a tough old squeezer that won't wear out

The donut-shaped steel disc in the main illustration is the mold plate used in a large hydraulic press. Under 2,000 tons of pressure, it squeezes an abrasive mixture in a mold to make grinding wheels. It's a tough job, and Waltham Grinding Wheel Company had to replace these discs every few months because they wore down and became unbalanced. Replacements were expensive and they wasted production time.

Finally, Waltham tried a plate made of USS "T-1" Steel. It has been used for more than a year now, and Waltham engineers say it will last indefinitely.

"T-1" constructional alloy steel has a minimum yield strength of 100,000 psi. It is exceptionally tough and resistant to abrasion—can be furnished heat treated to a minimum hardness of 321 Brinell. Compared to carbon steel, it has four times more resistance to atmospheric corrosion. In spite of its strength and toughness, "T-1" Steel can be formed, machined and welded. And because of its strength, it can be used in lighter gages, reducing weight as much as ⅔, depending on the application.

If you would like to have complete information about "T-1" Steel, write for our book "USS 'T-1' Steel," United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

USS and "T-1" are registered trademarks

USS

United States Steel Corporation—Pittsburgh
Columbia-Geneva Steel—San Francisco
Tennessee Coal & Iron—Fairfield, Alabama
United States Steel Supply—Steel Service Centers
United States Steel Export Company

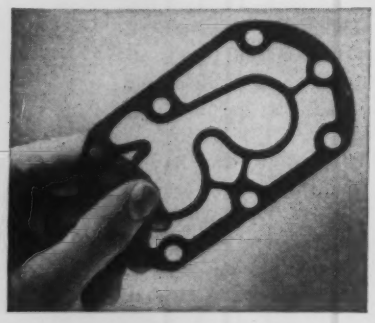
United States Steel

Please direct inquiries to advertiser, mentioning MACHINE DESIGN

Technical data for gasket design and selection

Choosing a gasket for compressors

In selecting a gasket material for a compressor head, the first consideration is the gasket's ability to withstand the usual ambient temperature of about 300° F.



At such elevated temperatures, and with internal pressures ranging well over 100 psi, torque retention becomes another critical factor.

In the case of refrigerator compressors, the choice of a gasket is further limited by the presence of refrigerant gases which attack many gasket materials.

A material that meets these requirements is Accopac AN-890, a new beater-saturated gasket material pioneered by Armstrong. Accopac AN-890 is a blend of refined asbestos fibers with a nitrile-type rubber binder.

AN-890 withstands temperatures up to 800° F. Its nitrile-type rubber binder swells slightly in the presence of refrigerant gases. Since these gases do not deteriorate AN-890, the swelling acts to maintain a tight seal.

Bolt torque retention of Accopac AN-890 has been proved by comparing a flange containing refrigerant gas at 350° F. and 150 psi, and a control flange at room temperature and no gas. Accopac maintained bolt torque equally well in both flanges.

Because of the thorough refining of the asbestos fibers, AN-890 die-cuts cleanly. It also costs less than conventional asbestos materials.

For more information, write for a copy of our new folder, IND-915.

How heat affects the selection of resilient gasket materials

In selecting a resilient gasket material for use where the temperature at the gasket line will be substantially higher than room temperature, the various effects of heat must be considered.

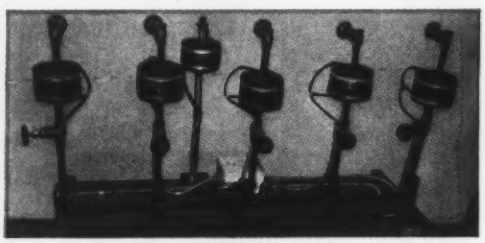
In many cases, heat is less of a limiting factor than is commonly supposed. If a designer knows the range of temperature limits of the various classes of resilient gasket materials (see table), he may find that a resilient material offers service equal to a more expensive gasket.

A more subtle effect of heat—and one more difficult to detect—is the softening it tends to produce in almost any non-metallic gasket.

Generally, this is manifested by things variously known as torque loss, stress relaxation, and creep. Because of plastic flow or some form of fatigue, high temperatures tend to reduce the ability of a resilient gasket to maintain flange pressures over relatively long periods.

Loss of bolt torque induced by heat can be minimized by selecting a gasket material with good torque retention properties. The Armstrong Accopac line includes several such materials. Generally, the denser the gasket the better its torque-retention properties, (see table). In addition, where heat is involved, it is all the more important that initial bolt loads be adequate.

A more complete discussion of the effects of heat on resilient materials is contained in the new Armstrong Gasket Design Manual. Write for your copy today.



This apparatus—called the "hot spider"—permits simultaneous testing of gasket materials at temperatures up to 750° F. and internal pressures up to 500 psi under varying conditions of flange loading.

Class of material	Maximum sustained temperature at gasket line*	Rank in order of torque retention
Asbestos	750° F.	1
Cellulose	300° F.	2
Cork-and-rubber	250° F.	3
Straight rubber	250° F.	4
Cork composition	250° F.	5

*These are recommended design limits. Obviously, in many applications temporary exposure to higher temperatures can be tolerated. Consideration should also be given to nature of contained fluids, since some fluids which are inert at room temperature become more active as temperatures increase.

Resilient gaskets usually are organic, and exposure to high temperatures can cause physical damage such as charring. If charring does occur, the damage will, of course, be obvious and leaks will result. This can generally be avoided by staying within recommended limits of the material or by using an inorganic gasket such as Armstrong asbestos Accopac.

Send for a copy of the new Gasket Design Manual, IND-763, containing 34 pages of valuable information for engineers. Armstrong Cork Co., 7009 Dean St., Lancaster, Penna.

Armstrong GASKET MATERIALS

. . . used wherever performance counts

the TROUBLE you save may be your own...

custom-engineered SHAFTS

by US® AXLE wear longer...in ANY application

Protection against down-time due to shaft failure on the equipment you sell, saves trouble for your customers . . . AND eliminates adjustments, replacement or rebuilding by YOU!

Plan U.S. AXLE SHAFTS into your equipment.

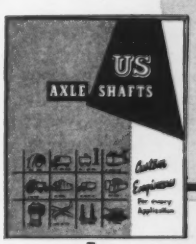
Custom-engineered to your specifications. Made from finest heat-treated alloy steels—U.S. Axles add dependability to your creative engineering . . . your equipment's performance. Egg-candling to coal handling . . . every shaft need is fulfilled better with U.S. AXLE SHAFTS.

Send us your blueprints and specifications for prompt quotations on your requirements.

"THE WORLD TURNS ON U. S. AXLES"

THE US AXLE COMPANY, INC.

Since 1920 • Pottstown, Pennsylvania



FREE

ILLUSTRATED BROCHURE

shows you why U.S. AXLE is your best source for precision-made special shafts

THE U. S. AXLE COMPANY, INC.
Pottstown, Penna.

Please send me the brochure on "U.S. Custom-Engineered Shafts."

Name _____

Firm _____

Address _____

City _____ Zone ___ State _____

NOW... Robbins & Myers Calculates a New Motor Design EVERY 1 to 6 MINUTES!

R&M Engineers Explore Hundreds of Design Combinations to Achieve OPTIMUM MOTOR PERFORMANCE!

How many ways *could* a motor be designed — a polyphase motor, for example? At least 27 basic variables offer 27^{27} (30 zeros) possibilities! Theory, of course, but still there's a colossal number even after obviously impractical designs are ignored. Working with slide rule, an engineer can calculate maybe four designs per day . . . and that's the time-consuming way it was done once. But now ROBBINS & MYERS engineers can explore hundreds of design possibilities, using their Data Processing System. With infallible accuracy, IBM's 20,000 digit "Magnetic Memory" is able to calculate a new motor design every one to six minutes! Because R&M engineers can now explore hundreds of design combinations before they make a final decision, you get the one motor that will deliver optimum on-the-job performance! And at no extra cost!

"Mechanized" mathematics at ROBBINS & MYERS also gives engineers more time for design *vision* and *decision*, which no machine can possibly provide . . . and enables them to improve existing motors by probing alternate design possibilities.

If you are ordering integral or fractional HP motors, or series motor parts, remember this fact: *the greater the number of practical design possibilities the manufacturer explores before the motor is produced, the better the motor will perform!* When your motor comes off the assembly line at ROBBINS & MYERS, you can be certain you are getting the best design possible, perfectly adapted to your requirements, and quality-built to perform dependably for years to come!

ROBBINS & MYERS, INC.

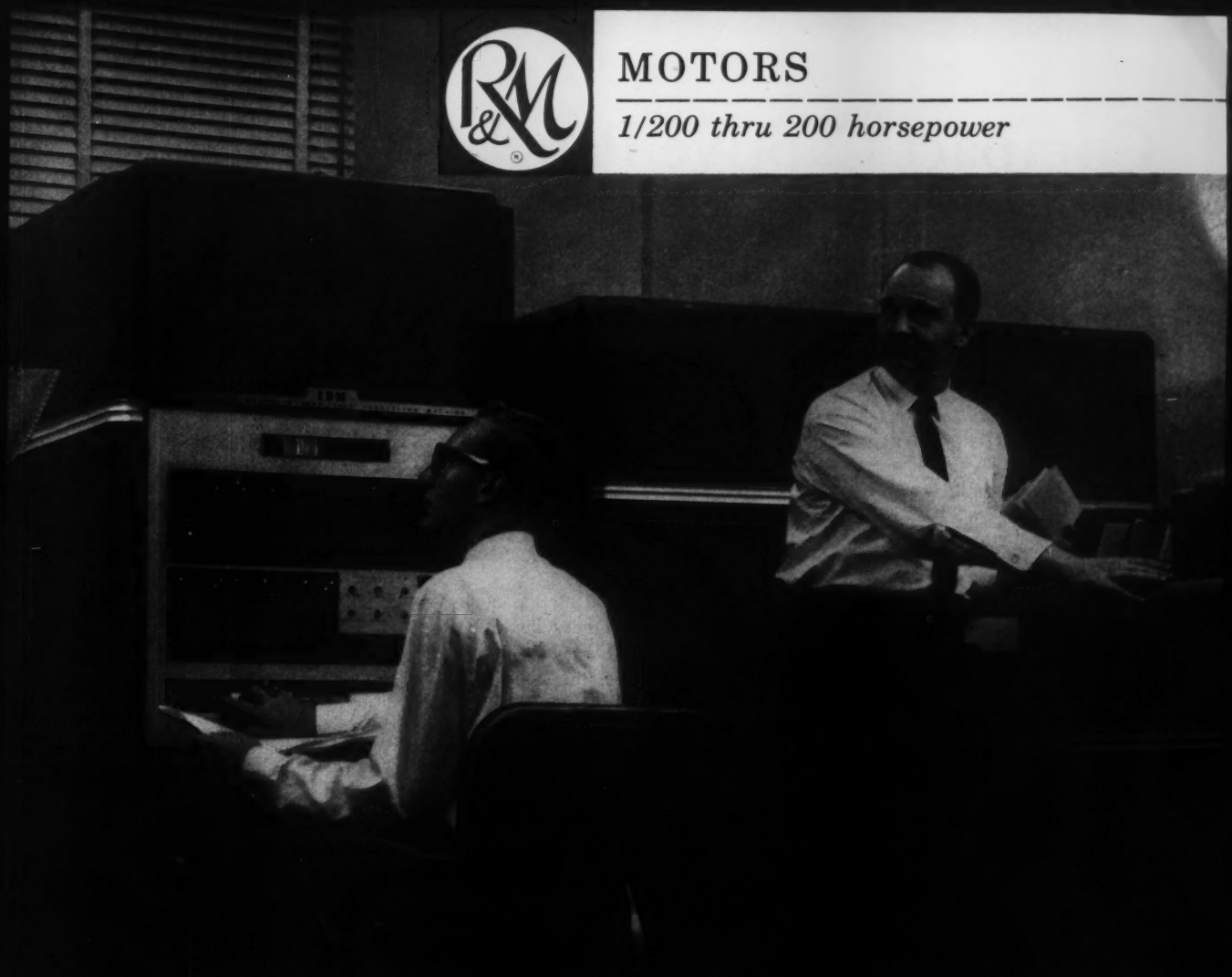
motors, household fans, Propellair industrial fans, hoists, Moyno industrial pumps

SPRINGFIELD, OHIO • BRANTFORD, ONTARIO

Circle 445 on Page 19

MOTORS

1/200 thru 200 horsepower



Design answers in seconds from IBM 20,000 digit magnetic memory!

Integral Motors (left), range from 1 to 200 HP in single-phase, direct current, polyphase, totally-enclosed fan-cooled, and explosion-proof types.

Standard Fractional HP Motors (right), are available in polyphase induction, capacitor start, resistance split-phase, and permanent split capacitor, in open and totally-enclosed types.

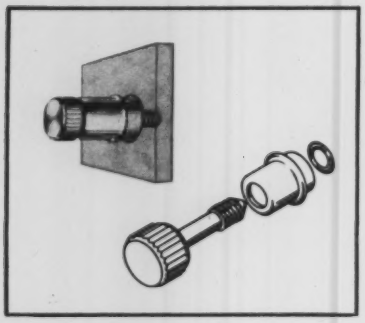
Precision-Made Universal Motors and Series Motor Parts (left), enable manufacturers of electric power-driven equipment to make the motor an integral part of their product.

Business Machine and Commercial Appliance Motors (right), are available in standard or custom designs.

Compact Captive Panel Screws:

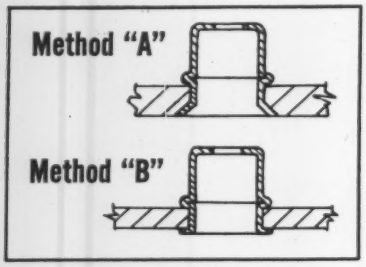
Standard Design Lowers Installed Costs

No longer is it necessary to resort to a costly fastening device of special design to provide quick attachment and release of electronic components. Standard Southco Retractable Screw Fasteners (stand-off thumb screws), available from stock, are both fast to install and economical. The five sizes,

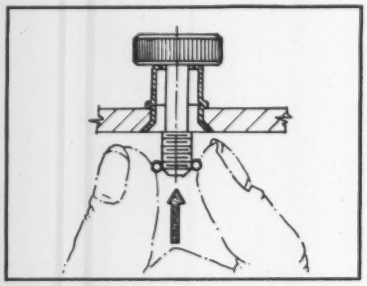


shown below, meet a very wide variety of requirements.

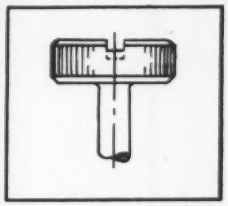
Check these advantages of simplified Southco Captive Panel Screws. Even when many screws are in one panel, misalignment is easily handled because the screw floats in a large hole in the stand-off, allowing ample play for "lining up." No special tools are



needed for installation, thus production is not subject to tool failure, nor limited by either the number of special tools available or the number of personnel trained in their use.



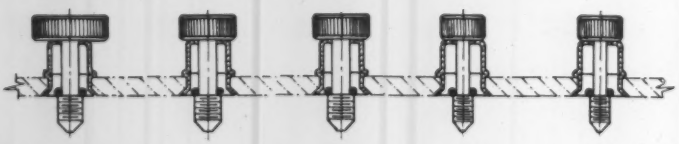
The Southco No. 58 Retractable Screw Fastener consists of three parts: thumb screw, stand-off, and retaining ring. The bright nickel-plated brass stand-off is inserted in either a drilled and countersunk hole (Method A), or a drilled hole (Method B), and flared. The polished, chrome-finished brass screw is passed through the hole in the stand-off and made captive by a retaining ring. Engaging in a tapped hole



in the frame, the screw may be fully withdrawn without moving the panel, yet always is retained.

The unslotted screw is standard in $\frac{3}{4}$", $\frac{9}{16}$", and $\frac{7}{16}$" head diameters and three thread sizes. Slotted head screws are also available in all sizes. The stand-off is standard in sizes to fit panel thicknesses from a minimum of $\frac{1}{16}$" to a maximum of $\frac{17}{64}$". Screw and stand-off are also obtainable in stainless steel.

MINIATURE TO LARGE SIZE HEADS IN FIVE TYPES



HEAD DIAMETER	3/4"	9/16"	9/16"	7/16"	7/16"
THREAD SIZE	1/4-20	1/4-20	12-24	10-24	10-32

Free Fastener Handbook

Send for your complete Southco Fastener Handbook, just printed. Write to Southco Division, South Chester Corporation, 237 Industrial Highway, Lester, Pa.

SOUTHCO FASTENERS

LION

©1959

Hydraulic Cylinder Manufacturer Specifies

Loading a minimum quantity of Ostuco tubing at the Shelby mill — in this instance only 150 feet.

"When you make hydraulic cylinders in 11 bore sizes . . . dozens of different pressure ratings . . . a variety of wall thicknesses and analyses — you've got a man-size tubing inventory problem.

"That's why we switched to Ostuco tubing made to our *exact specifications*. We like its availability in truly *small minimum quantities*. And with its consistently close tolerances, shipment after shipment, Ostuco tubing has *cut our machining time over 50 percent* . . ."

This is an actual case history of a manufacturer with a severe inventory problem. He required special tubing grades in minimum quantities. If you're faced with a similar situation, it's time you contacted your Ohio Seamless representative, listed in the Yellow Pages, or the mill at *Shelby, Ohio — Birthplace of the Seamless Steel Tube Industry in America.*

AA-5843

OHIO SEAMLESS TUBE DIVISION

of Copperweld Steel Company · SHELBY, OHIO

Seamless and Electric Resistance Welded Steel Tubing • Fabricating and Forging

SALES OFFICES: Birmingham, Charlotte, Chicago (Oak Park), Cleveland, Dayton, Denver, Detroit (Huntington Woods), Houston, Los Angeles (Lynwood), Miami, Moline, New Orleans (Chalmette), New York, North Kansas City, Philadelphia (Wynnewood), Pittsburgh, Rochester, St. Louis, St. Paul, Salt Lake City, Seattle, Tulsa, Wichita CANADA: Railway & Power Engr. Corp., Ltd. EXPORT: Copperweld Steel International Company, 225 Broadway, New York 7, New York

The X-ray fluorescence analyzer, one of the many modern instruments in the chemical laboratory, helps Jessop make certain you get the specified per cent of each alloy in your specialty steel.

"How X-rays help Jessop give you exactly what you want in alloy steels . . ."

—C. M. Carlisle, Director of Analytical Chemistry

"What's happening here? As the stylus in the X-ray fluorescence analyzer draws red lines on the graph, the Jessop chemist determines the exact per cent of each alloy in a sample of specialty steel.

"Based on this analysis, the melter may ask for the addition of, say, molybdenum to the molten steel now in electric arc furnace No. 3.

"How's it done? Bombarded by X-rays, the alloys in the sample of steel are radiating secondary rays. Converted into electrical energy, the rays are causing the stylus to move and draw red lines on the graph . . . indicating the types and per cent of alloys in the steel sample."

In the Jessop chemical laboratory, the X-ray fluorescence analyzer and many other modern instruments help us make certain you get the exact chemical composition specified in your order. This chemical laboratory is one more reason for your confidence in ordering specialty steels from Jessop. *Specify Jessop . . . and then relax!*

JESSOP
STEEL COMPANY
Washington, Pennsylvania

VMA 6720

Subsidiary Companies:
Green River Steel Corporation, Owensboro, Kentucky • Jessop Steel International Corporation, New York City
Jessop Steel of Canada, Ltd., Wallaceburg, Ontario • Steel Warehousing Corporation, Chicago, Ill.

Stainless, alloy, tool, cast-to-shape, and forging steels, precision ground flat stock, and other specialty steels

Circle 448 on Page 19

S. S. White DRIVE AND CONTROL IDEAS FOR ENGINEERS

Tips on better designing with flexible shafts

More Savings with Ready-to-Attach S. S. White Standard Flexible Shafts

NEW, EXTRA-HEAVY-DUTY SHAFT ADDED TO "OFF-THE-SHELF" LINE

Here's a time and money saving idea... the majority of flexible shaft needs can be met with ready-to-attach S. S. White **standard** flexible shafts.

This line has been recently expanded by the addition of the .500" dia. standard shaft to handle extra-heavy loads.

Flexible shafts allow you to simplify design ... position controls and driven parts to best advantage... eliminate expensive gears, universals, rods and costly alignment problems.

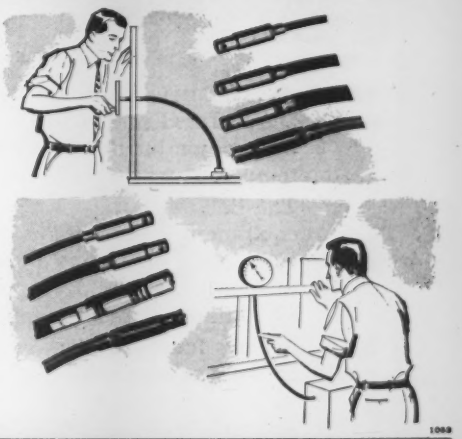
S. S. White **standard** flexible shafts are low in cost and readily available because they are **stock** items. They save you engineering time because the designing has already been done for you by S. S. White, first name in flexible shafts. **They come complete and ready to attach directly to your mating spindle.**

Another plus! Convenient, low-cost, readily available, S. S. White standard flexible shafts are the ideal way to test the advantages of flexible shafts in your products.

Where to use S. S. White Standard Flexible Shafts

REMOTE CONTROL of valves, actuators, switches, indicators and other mechanical or electrical equipment. S. S. White standard remote control flexible shafts come in four different shaft diameters to handle a wide range of requirements.

POWER DRIVE for an endless variety of applications ... portable tools, instrument drives, machine tools, pumps ... anywhere the designer needs to transmit power around obstructions or to movable parts, by means of a single, self-contained, easily applied unit. Four standard sizes.



S. S. White IN FLEXIBLE SHAFTS

S. S. WHITE INDUSTRIAL DIVISION (Dept. 4)
10 East 40th Street, New York 16, N.Y.

Selection of S. S. White standard flexible shafts: complete description and application data available. **Write for bulletin 5801.**

WRITE FOR COMPLETE DATA!

Selection of specialized flexible shafts to meet unusual requirements: useful shaft data and also information on how to take advantage of S. S. White engineering services. **Write for bulletin 5601.**

New! AIR CONTROL UNITS

Automatically

- ★ Filter pressurized air to provide a clean, dry air supply
- ★ Compensate for fluctuations in air pressure delivered by the air supply system
- ★ Compensate for variations in cfm requirements of pneumatic equipment
- ★ Adjust amount of misted lubricant to meet changing cycle rates or surge demands

The new Bellows Lubri-Air® Control Unit

T.M. Registered
Pat. Pending

● This new Lubri-Air Control Unit, made by The Bellows Co., and sold and serviced by Bellows and Valvair Corporation Field Engineers, is a major break through to the problem of supplying clean, dry, pressure-regulated and properly lubricated air to pneumatic equipment.

The Bellows Lubri-Air Control Unit, once set to match the needs of the equipment it serves, automatically removes dirt and moisture from the air stream, maintains a constant down stream pressure regardless of fluctuations in supply pressure or in cfm requirements, and feeds a correct amount of misted oil to the air stream regardless of variations in the air flow rate.

Bellows Lubri-Air Control Units assure continuous top working efficiency as well as maximum long life with minimum maintenance from air-powered equipment.

Available for immediate delivery in the ¼", ⅜" and ½" sizes. ¾" and 1" sizes shortly.

See your Bellows-Valvair Field Engineer or write direct to Dept. MD-959, The Bellows Co., Akron 9, Ohio, for descriptive Bulletin LA-15.

14978

The Bellows Co.
DIVISION OF INTERNATIONAL BASIC ECONOMY CORPORATION (IBEC)
AKRON 9, OHIO

OTHER INDUSTRIAL DIVISIONS OF IBEC: Sinclair-Collins Valve Co., Valvair, Akron, Ohio • V. D. Anderson Co., Cleveland, Ohio

Circle 450 on Page 19

Circle 451 on Page 19→

Pay less for more strength! Tenzaloy the self-aging aluminum alloy needs no heat treatment! If your aluminum castings are too large or too intricate for heat treatment, if your heat treating facilities are limited, if you need superior strength than you get from ordinary heat-treated alloy demand "Federated Tenzaloy" developed by Federated to meet the need for a superior aluminum alloy that ages at room temperature. Tenzaloy eliminates rejects due to warpage, expansion, and internal stresses caused by quenching. Tenzaloy finished properties are stable, proved by conclusive test data over a ten year period. No special foundry techniques are required. No fluxes. Castability is excellent with sand cast and plaster molds and many permanent molds. Tenzaloy will not "grow," produces corrosion-resistant castings with excellent polishing characteristics and anodizes clear white. Write for Tenzaloy Bulletin No. 103. Federated Metals Division, 120 Broadway, New York 5. In Canada: Federated Metals Canada, Ltd., Toronto and Montreal.

FEDERATED METALS DIVISION OF

ASARCO

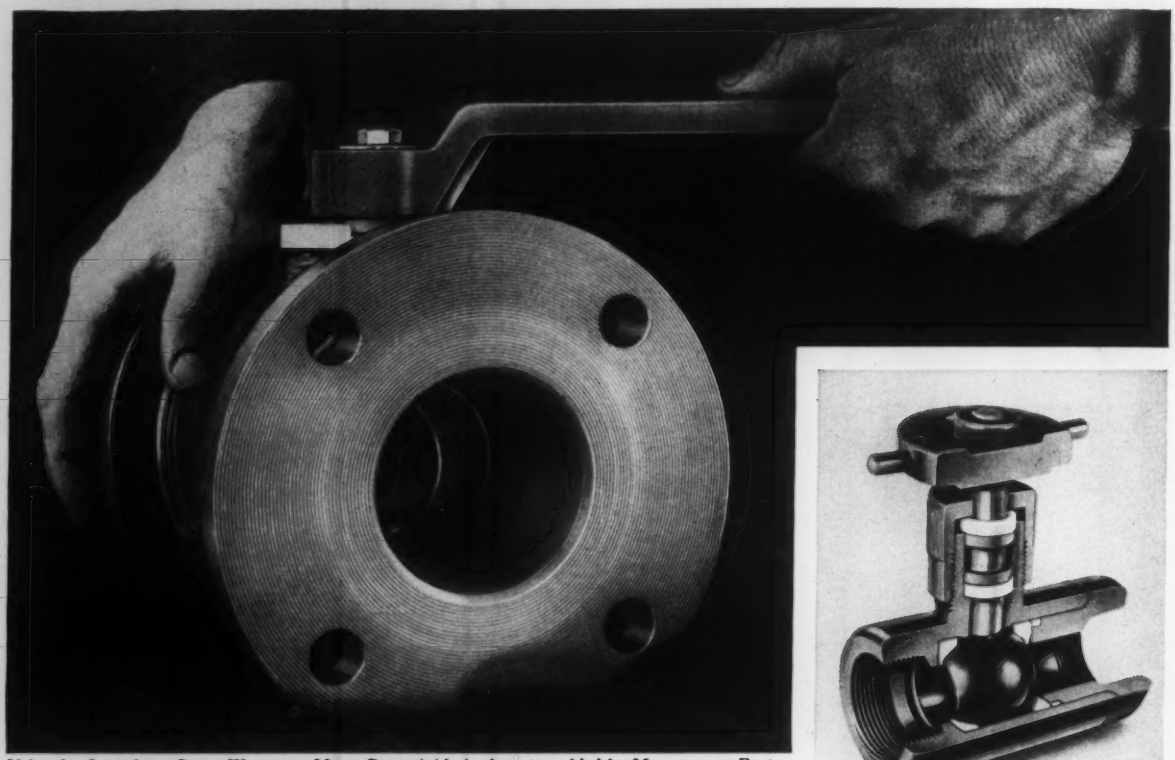
AMERICAN SMELTING AND REFINING COMPANY

TENZALOY is one of a complete series of Federated aluminum casting alloys. A new plant in Alton, Ill. will soon be in production to satisfy the requirements for Tenzaloy in the mid-west.

58-28

News about

B.F.Goodrich Chemical *raw materials*



Valves by Jamesbury Corp., Worcester, Mass. Geon rigid vinyl parts molded by Mannesman-Easton Plastic Products, Inc., Easton, Pa. Valves in sizes from 1/2" to 4", shown in large photograph, are rated at 150 psi to 100 F. and at 50 psi to 130 F. They can be remote operated. B.F.Goodrich Chemical Company supplies the Geon rigid vinyl material only.

New ball valve of Geon helps piping systems fight corrosion

Thousands of test cycles with this new valve made from Geon rigid vinyl have proved the effectiveness of its seal, either at full pressure or vacuum. Since it is made entirely of Geon except for seats and seals, it offers pipe users another weapon for the battle against corrosion. Geon offers superior resistance to oils, acids, alkalies and most chemicals.

In addition, rigid Geon weighs less than metal. Shipping weights are lower, installation is easier. These valves can be obtained with threaded ends, weld ends, or flanges. They are self-compensating for changes in pressure or temperature. There is no problem of galling or seizure. No lubrication is needed.

Geon offers remarkably varied opportunities for products that open new markets or improve present applications. In rigid form it is being used for pipe, window frames and ductwork . . . in other forms for weatherstrip, wall coverings, foam products, or coatings for metal, paper or textiles. One member of the Geon family can surely help you make a better product. Write for information to Dept. AS-4, B.F.Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

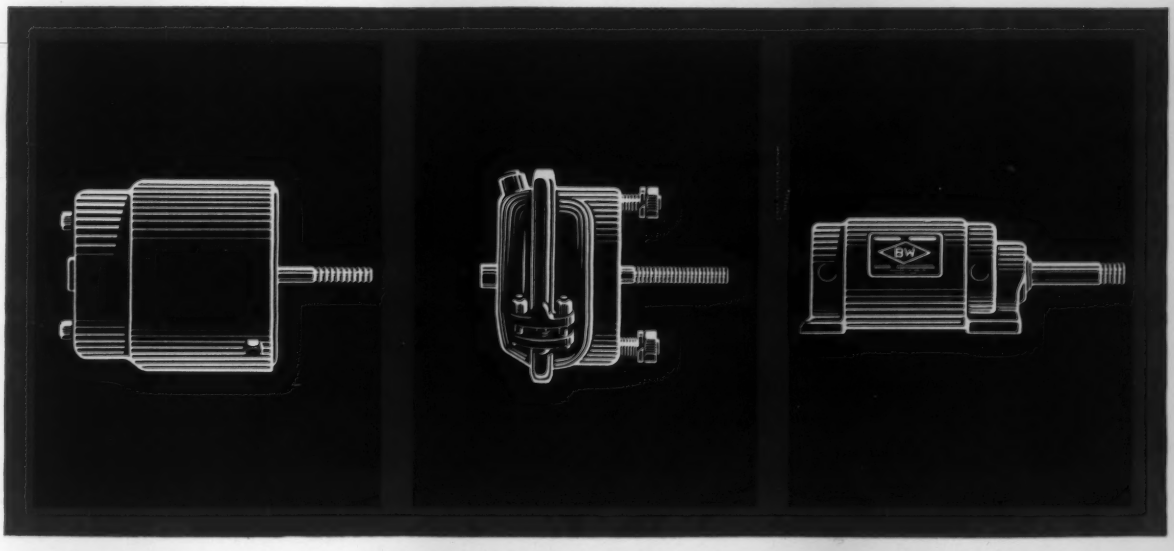
B.F.Goodrich Chemical Company
a division of The B.F.Goodrich Company

B.F.Goodrich

GEON polyvinyl materials • HYCAR rubber and latex
GOOD-RITE chemicals and plasticizers • HARMON colors

DEPENDABLE POWER CYLINDERS FOR EVERY APPLICATION

It will pay you to investigate the complete line of Bendix-Westinghouse air and hydraulic cylinders. Whatever your requirements, you'll find that Bendix-Westinghouse can fill *every* industrial application for precise, dependable, long-life air or hydraulic controls. Our substantial inventory of standard cylinders assures prompt delivery. Should you require equipment for a special application, we can custom-build power cylinders tailored to your individual specifications. And they're all backed by the Bendix-Westinghouse name—your solid guarantee of high quality and complete satisfaction. Write today for full information on how Bendix-Westinghouse industrial controls can make your job easier and save you money.



ROTOCHAMBERS. Frictionless. Leakproof. Neoprene diaphragm has a rolling action and exceptionally long life. Chrome molybdenum steel push rod. Available nine sizes delivering from 900 to 5000 pounds force at 100 psi air pressure.

ROBOTAIR CHAMBERS. Small overall diameter. No lubrication or filtering required. High grade steel stamping. Rubber diaphragm has flexing action. Leakproof. Available nine sizes delivering from 300 to 3600 pounds force at 100 psi air pressure.

POWER CYLINDERS. Piston-type air and hydraulic. Heavy wall steel tubing, precision honed. Head and mount are integral castings. High-tensile, heavily chromed rod with metal rod scraper. Available in all mountings and sizes.

Bendix-Westinghouse

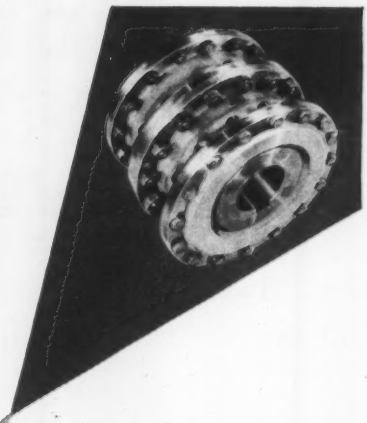
BW

INDUSTRIAL PRODUCTS

Bendix-Westinghouse Automotive Air Brake Company, Elyria, Ohio

Circle 453 on Page 19

the basic coupling principle that couldn't be improved...



This principle makes every Fast's coupling ...large or small ...out-perform all others

The principle embodied in Koppers gear-type, self-aligning Fast's couplings couldn't be improved by anyone. Throughout industry, Fast's couplings are accepted as the most dependable couplings on the market. Experience has proved that they frequently *outlast the equipment* they connect.

Fast's couplings are sufficiently comprehensive in types, sizes and versatility to meet almost every known need for couplings. Available in forged steel for shaft sizes from ¾″ to 6⅝″ and in cast steel for shaft sizes from 5½″ to 32″.

Nearly 40 years of coupling experience guarantees that Koppers can supply the right coupling engineered for a given application. For the booklet describing Fast's couplings applicable to your equipment, write today to: KOPPERS COMPANY, INC., Fast's Coupling Department, 5609 Scott Street, Baltimore 3, Maryland.

KOPPERS

THE ORIGINAL

FAST'S Couplings

Engineered Products Sold with *Service*

thermal thicket

Problem: *The heat barrier which now hinders hypersonic aircraft and missiles.*

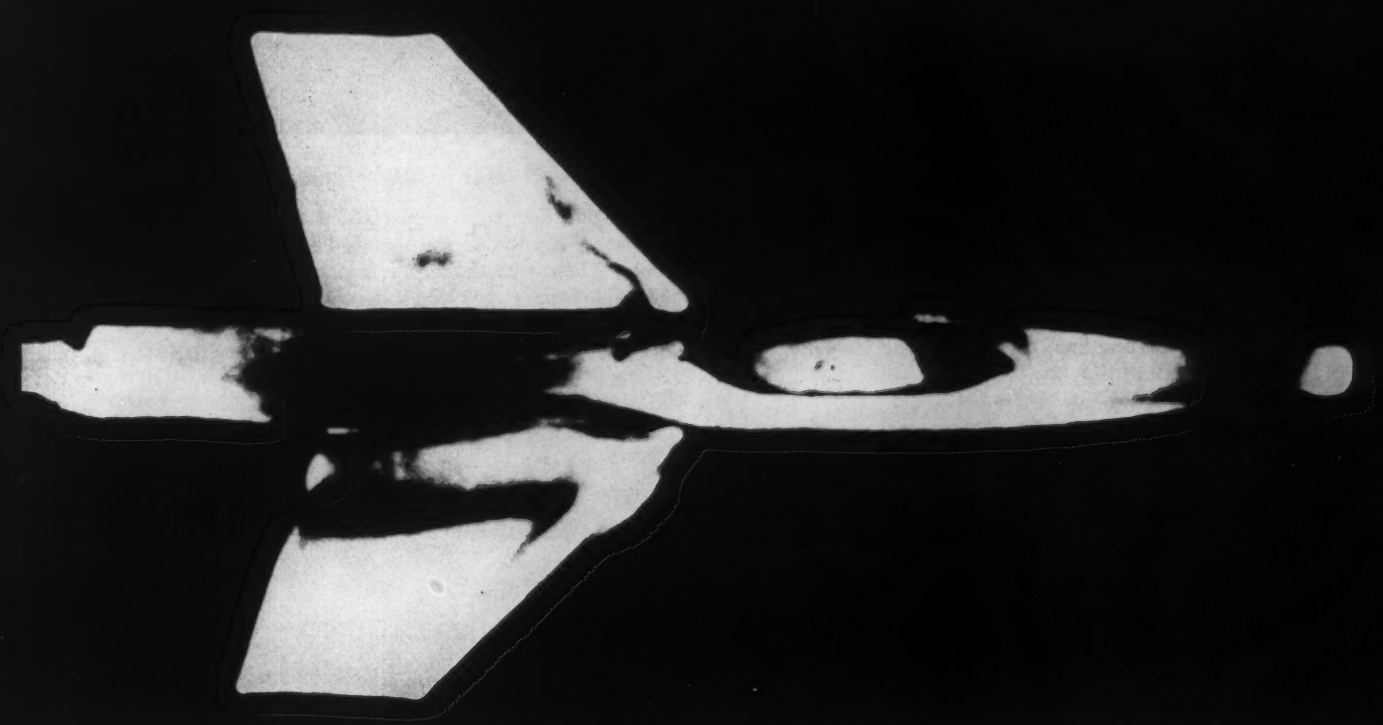
Needed: *Dependable high temperature alloys for structural components.*

Solution: *Find the right alloys that are easy to forge and machine and are truly uniform.*

Source: *Predictable performance Carpenter alloys made by the exclusive Mel-Trol, VacuMeltrol and Consumet melting processes.*

Engine builders find them ideal for many critical parts. Forge shops report improved forgeability resulting in better finishes requiring far less machining. Work goes faster. Rejects are fewer.

Call your local Carpenter Representative for the whole story about predictable performance alloys and how they can benefit you. The Carpenter Steel Company, Reading, Pa.



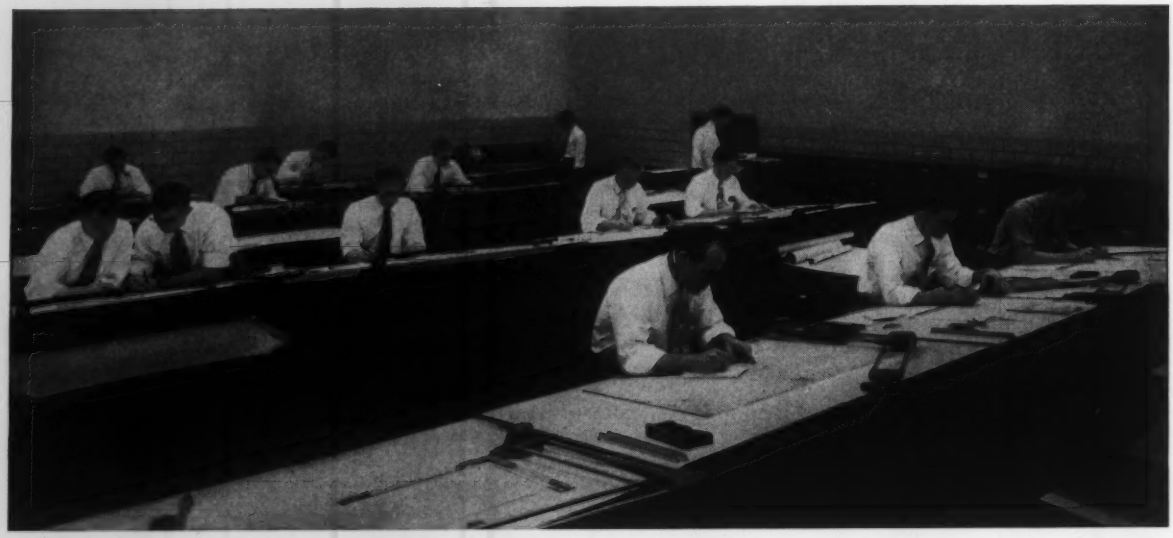
a new company 70 years old

Carpenter steel

The Carpenter Steel Company, Main Office and Mills, Reading, Pa.
Alloy Tube Division, Union, N. J.
Webb Wire Division, New Brunswick, N. J.
Carpenter Steel of New England, Inc., Bridgeport, Conn.

Circle 455 on Page 19

...how four of the engineering help you...the



❶ **The advanced product and process engineers** at each of our plants are available to assist you with the casting design considerations. It is Central Foundry's practice to suggest design changes that ordinarily do not affect the part functionally, but often reduce casting weight, thus reducing casting costs. Your blueprints are returned to you with parting line, coring and gate locations as well as suggested changes in casting design clearly marked.

Our engineering staff is specialized to give you expert assistance in each of the metals Central Foundry produces. When you are considering castings of ArmaSteel, malleable iron or grey iron to be cast in either green sand molds or by the more exacting shell mold process, contact the sales department of Central Foundry Division.

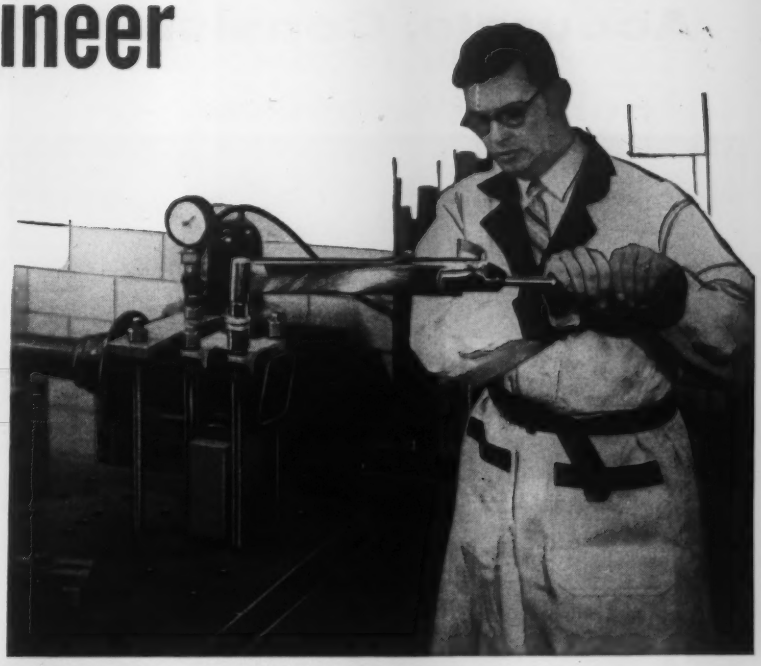
❷ **Cobalt 60 radiography,** a fast, positive method of detecting sub-surface defects, has replaced time consuming breaking, cutting and etching of castings, formerly used by the foundry industry to check new parts for soundness. This technique does not demand destruction of the part and gives positive location of any defects. With radiographs as a guide, our engineers can make necessary changes in gating, feeding and general design that assure quality castings at reduced cost, and do it in hours compared to days required for breaking or cutting.

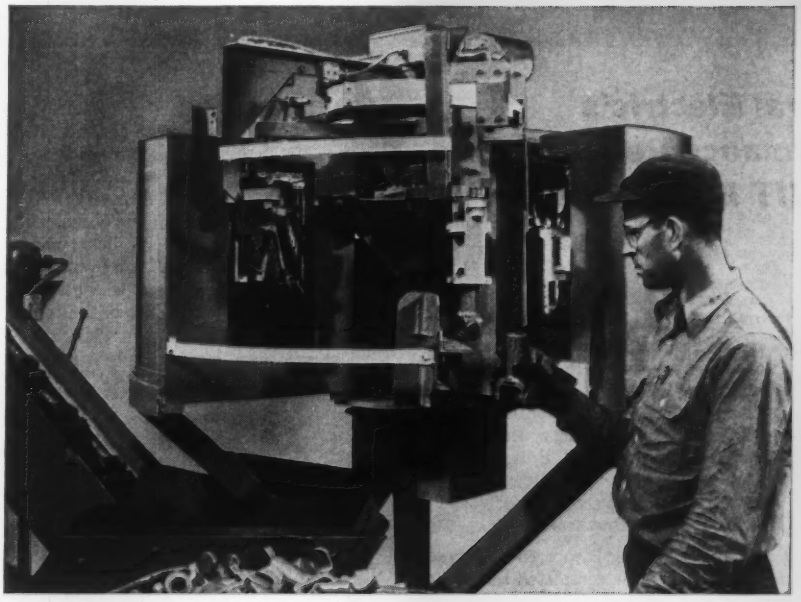
CENTRAL FOUNDRY DIVISION · GENERAL MOTORS CORPORATION

CENTRAL FOUNDRY DIVISION

services at Central Foundry design engineer

3 Stress Analysis is also used at Central Foundry in the design or redesign of castings to reduce weight and improve mechanical strength. By an accurate study of stress, both statically and dynamically, Central Foundry engineers are able to suggest design changes, to put metal where it is needed, remove excess material, to recommend the best material for your part and thus assure the highest quality castings at the lowest possible cost.





4 Sonic testing is an electronic listening device developed by Central Foundry that automatically distinguishes between the vibrations of good and faulty castings and sorts them accordingly. The sonic testing machine, much faster and more accurate than visual inspection, eliminates human error and is ideally suited to high production of castings designed for critical applications.

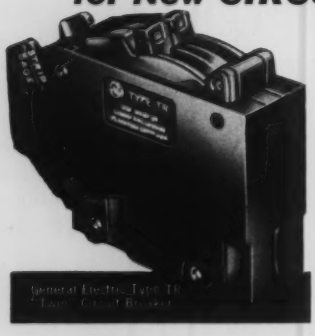
Central Foundry, with plants in Saginaw, Michigan, Defiance, Ohio, and Danville, Illinois, has the vast facilities and engineering services necessary to deliver, on schedule, quality castings in production quantities. Our sales engineers, product development engineers, foundry engineers and modern engineering services are all available to help you get quality castings . . . at low cost . . . in less time.

GENERAL MOTORS CORPORATION • SAGINAW, MICHIGAN • DEPT. 14

MEMBER MALLEABLE CASTINGS COUNCIL

Accurate, Consistent Performance

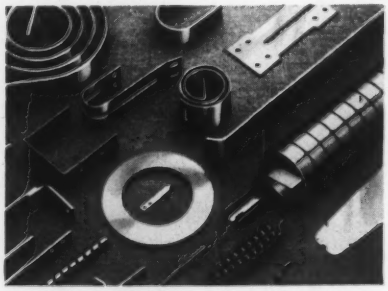
Meets General Electric's High Material Performance Requirements for New CIRCUIT BREAKERS



The new General Electric "Twin"* Circuit Breaker for household applications combines two rugged breakers into a single one-inch case to allow up to twice as many circuits per load center. Because quality and dependability are a must, General Electric Circuit Protective Devices Department used TRUFLEX Thermostat Metal parts in their Type TR "Twin"* Circuit Breakers.

TRUFLEX is available in cut strips or long-length coils to meet your needs, or can be furnished in formed elements or completed assemblies fabricated to the most exacting parts' specifications. Either way you get accurate, consistent performance with TRUFLEX because every repeat order is an exact duplicate of the original — dependably uniform in activity, temperature range, electrical and corrosion resistance.

To new or regular users of thermostat metal, Metals & Controls has much to offer — over 60 types of TRUFLEX Thermostat Metal (resistivity from 15 to 850 ohms per c.m.f.) — complete technical literature on TRUFLEX — help with parts design — calibrated samples. Our competent field engineers will gladly call at your request. No obligation. Write today.



A few typical TRUFLEX formed elements fabricated for many Metals & Controls' customers.

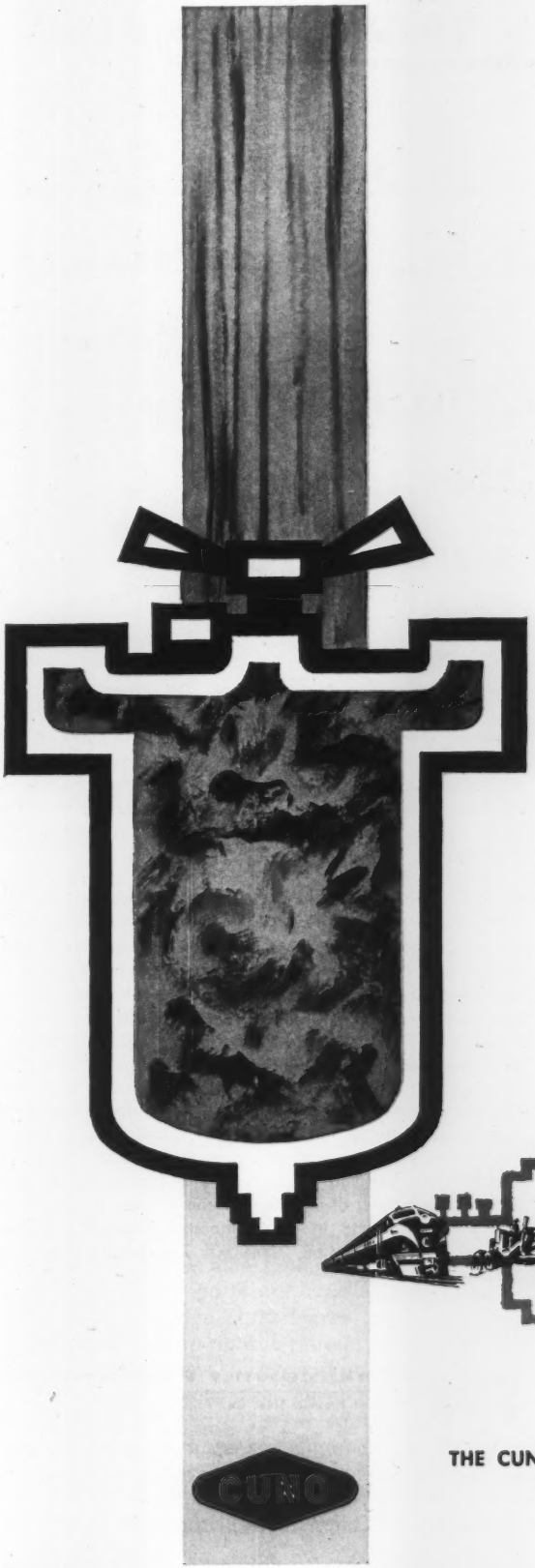
*"Twin" Registered Trademark General Electric Company

METALS & CONTROLS

809 FOREST STREET, ATTLEBORO, MASS., U. S. A.

A DIVISION OF TEXAS INSTRUMENTS INCORPORATED

GENERAL PLATE PRODUCTS: Clad Metals • Electrical Contacts • Truflex® Thermostat Metal • Platinum Metals • Reactor Metals • Radio Tube & Transistor Metals

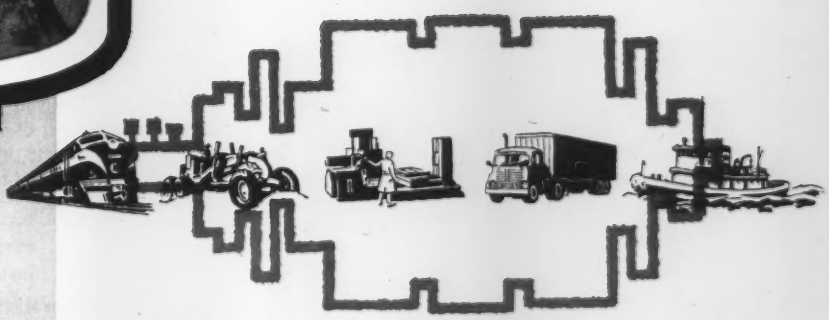


whatever the **power production application...** you can depend on **CUNO** engineered filtration

"The more complete the filtration, the more efficient the production of power." Cuno filters remove damaging contaminates and reduce costly stoppages.

To meet the specific requirements of *your* power production application, Cuno provides effective, engineered filtration with... Auto-Kleen Self-Cleaning Edge-Type, Flo-Kleen Automatic Self-Cleaning Wire Wound, Micro-Kleen Disposable Depth Cartridge... available in a variety of housings.

Let us apply over 30 years of filtration know-how to *your* requirements.



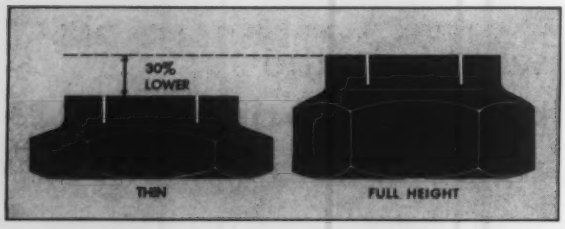
THE CUNO ENGINEERING CORP., DEPT. 12, MERIDEN, CONN.

A Leader in Industrial Filtration for More Than 30 Years

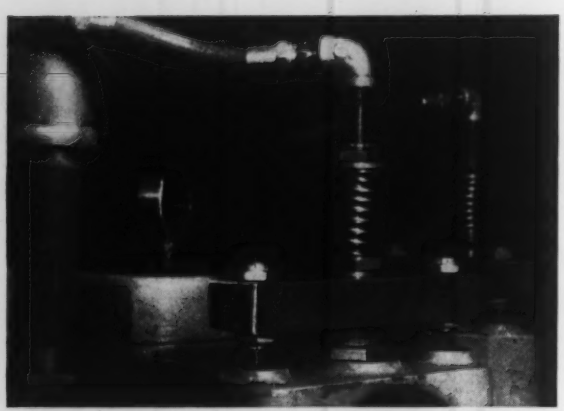
Sales Offices throughout the United States and Canada
In Canada write: Peacock Bros., Ltd., P.O. Box 1040, Montreal 3, P.Q.

Circle 458 on Page 19

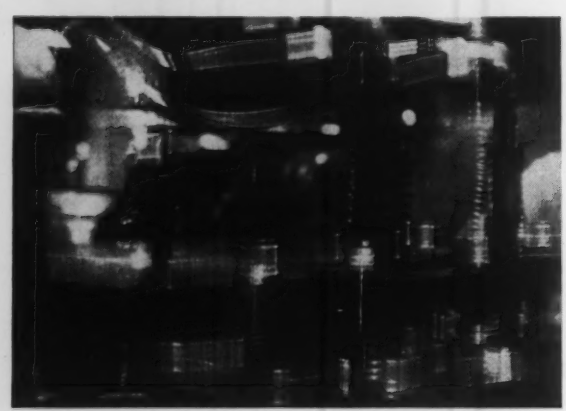
SPS RELIABILITY / *A dynamic standard of predictable performance*



FLEXLOC self-locking thin nuts help you design more compact bolted joints



Spring compression bar assembly on a finishing machine demonstrates use of FLEXLOC thin nuts in both locknut and stop nut applications. Thin nuts lock with shorter bolts, thus help solve clearance problems and save weight.



Stroboscopic photo shows same unit in operation. Nuts stay tight despite constant vibration. FLEXLOC thin nuts provide high locking reliability because every thread, including locking threads, carries its full share of the load.

FLEXLOC self-locking thin nuts are 30% lower—and correspondingly lighter—than full locknuts of the same nominal diameter. They lock with shorter bolts and fit in places where ordinary-height locknuts will not go. With FLEXLOC thin nuts, you can design smaller, lighter joints . . . without sacrificing reliability. This is because in a FLEXLOC, every thread, including those in the locking section, carries its full share of the tensile load.

Besides saving weight and space, FLEXLOC self-locking thin nuts require no auxiliary locking elements—no lockwashers, jam nuts or cotter pins. There is nothing extra to put together, come apart or get lost. Thus FLEXLOC thin nuts facilitate design and specification, simplify inventory and handling, reduce assembly time and costs. They also save on maintenance, because they can be removed and reused repeatedly without impairing their locking reliability.

You can utilize FLEXLOC thin nuts as locknuts or stop nuts. They lock, seated or not, wherever wrenching stops and will not vibrate loose. For complete information on sizes, materials and finishes, see your authorized SPS distributor. Or write SPS—manufacturer of precision threaded industrial fasteners and allied products in many metals, including titanium. Flexloc Locknut Division, STANDARD PRESSED STEEL CO., Jenkintown 18, Pa.

SPS **Jenkintown • Pennsylvania**

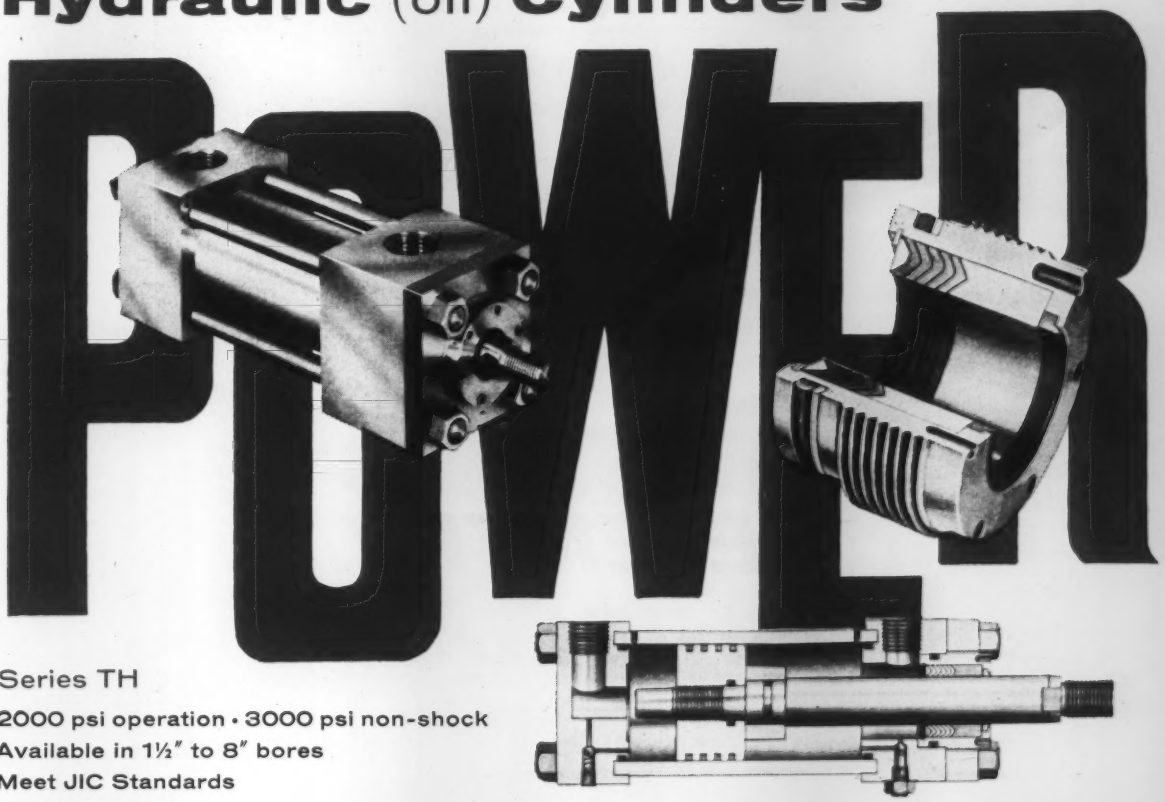
Standard Pressed Steel Co. • The Cleveland Cap Screw Co. • Columbia Steel Equipment Co. • National Machine Products Co. • Nutt-Shel Co. • SPS Western • Standco Canada Ltd. • Unbrako Socket Screw Co., Ltd.

there is **power**

to spare in

O-M heavy-duty

Hydraulic (oil) **Cylinders**



Series TH

2000 psi operation • 3000 psi non-shock
Available in 1½" to 8" bores
Meet JIC Standards

IF you need smooth, dependable straight-line motion for heavy-duty pushing, pulling, elevating, lowering, clamping or knock-out operations, these powerful, O-M components have what it takes and more, too. To deliver this plus in power, every essential design and construction feature has been employed.

For example, these units are ruggedly constructed of heavy wall seamless steel tubing microhoned to minimize friction. The ports are large and unrestricted. They can be located at 90-degree positions. These cylinders are sealed right to prevent power loss. The piston rod is stress relieved, turned, ground and polished, high tensile steel, chrome plated. In addition, the rod gland cartridge, accurately piloted in the rod head to assure perfect alignment, is easily unscrewed and removed. Pilot O.D. of cartridge serves as pilot for cylinders mounted on rod end. A cushion ball check valve provides for rapid, full power start of return stroke.

These and many other advancements are described in our latest catalog No. 105. Write for your copy TODAY or consult your local O-M representative.

ORTMAN-MILLER MACHINE COMPANY
7 143rd Street, Hammond, Indiana

☐ Have representative call
☐ Send Bulletin 105

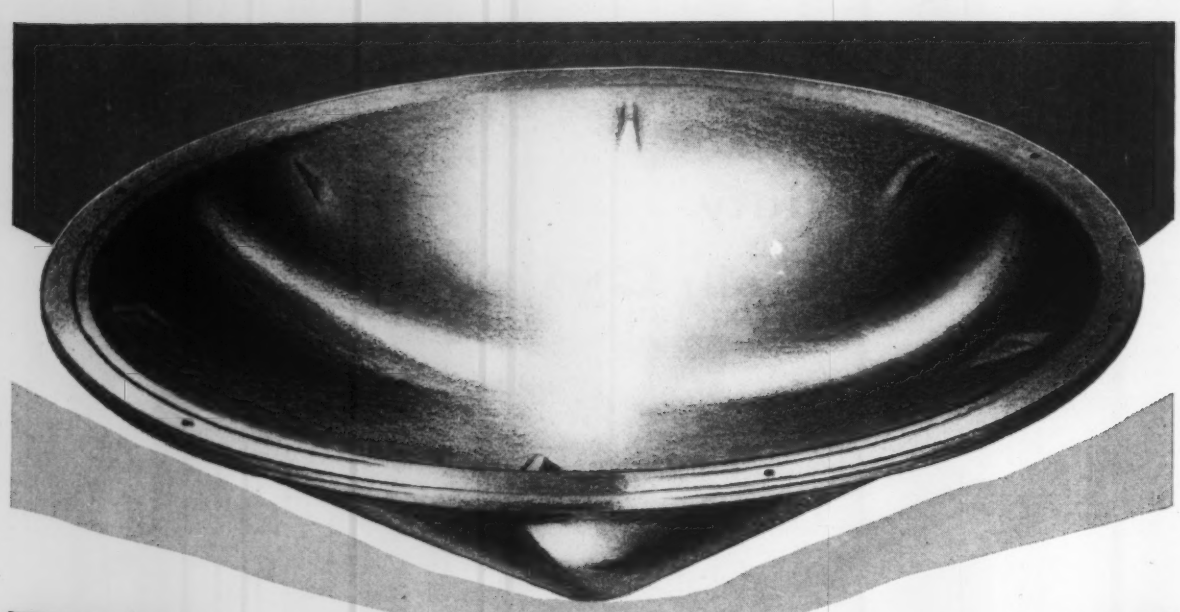
Name_____ Position_____

Company_____

Address_____

City_____ Zone_____ State_____

Circle 460 on Page 19



RE-ENTRY SHIELDS

EST. 1883

WYMAN-GORDON IS FORGING RE-ENTRY SHIELDS

- Copper in production
- Beryllium in limited production
- Reinforced plastics in development

WYMAN-GORDON

FORGING

ALUMINUM MAGNESIUM STEEL TITANIUM BERYLLIUM MOLYBDENUM COLUMBIUM
AND OTHER UNCOMMON MATERIALS

WORCESTER, MASSACHUSETTS

HARVEY, ILLINOIS
DETROIT, MICHIGAN
GRAFTON, MASSACHUSETTS
FORT WORTH, TEXAS
FRANKLIN PARK, ILLINOIS
LOS ANGELES, CALIFORNIA

Circle 461 on Page 19

the neg'ator® sketchbook

The NEG'ATOR® Spring is a new basic mechanical component—a coiled band spring which extends many times its original size without the increasing force common to conventional springs. Used as an extension spring, a motor, band, clamp, or clip, this revolutionary new constant-force component upsets all previous spring principles by doing what springs have never done before.

TECHNICAL MAGAZINE ARTICLES SHOW HOW DESIGNERS ARE USING NEG'ATOR® SPRINGS TO IMPROVE PRODUCTS

Assembled Clippings Make a Good "Idea File" for Engineers

· PRODUCT ENGINEERING

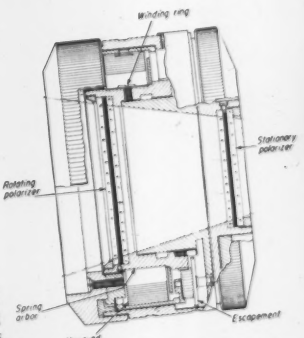
DESIGN FEATURES

Prestressed Spring Drives Camera Aid

Device mounts on lens of a hand-held movie camera, gives professional-looking fade-out effect to picture sequence.

Prestressing, then backcoiling flat spiral spring allows storing more energy in a small space. Wollensack Optical Co., Rochester, N. Y., designed the device, made possible by a spring-winding technique developed by the Hunter Spring Co., Lansdale, Penna.

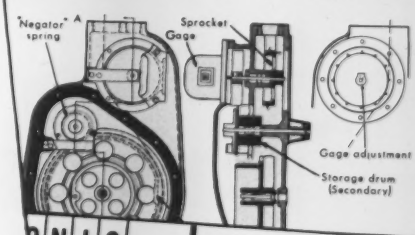
Fading action . . . occurs when photographer presses cable release. This starts spring motor that rotates one of a pair of polarizing filters. Fadeout is complete after the front filter rotates 90°, at this point also, a two-bladed shutter closes to shut out all light. A simple escapement controls fading speed—one dissolve taking about ¼ sec. The motor drives the filter through 2½ revolutions on one winding, enough for five dissolves followed by equal number of fade-ins. An internal lock stops the action after each 90° rotation. Flag marked "open" pops out when filter grids are parallel, allowing full image.



Large-diameter arbor . . . was needed to pass enough light through filters to camera lens. Also, outside diameter was limited to size convenient for use on hand-held camera. Spring motor had to fit annular space between 1.410-in. OD arbor and 1.930-in. ID restraining [illegible]

· DESIGN NEWS

Rate Compensates for Tape Length



COMPENSATION IN [illegible] is obtained by designing [illegible] creasing deflection rate. [illegible] unwinds from a primary [illegible] a secondary drum, its [illegible] force balancers and compe[illegible] added weight due to unw[illegible] stainless steel tape. In the [illegible] float maintains a constant [illegible] ship with fluid level, in[illegible] of tape length. All shafts i[illegible] are stainless steel and are [illegible] on "Rulon" bearings. This [illegible] minimum friction and du[illegible] quire lubrication. Spring [illegible] in fine drawing in color. [illegible] of factors, such as decreas[illegible] eter on primary drum an[illegible] ing diameter on secondar[illegible] were considered in c[illegible]

· ELECTRONIC DESIGN

Keep Instrument Cables Out Of the Way

HOW TO keep thick, bulky electrical cables out of the way when drawer-mounted chassis are pushed back into cabinets—that's a problem. It puzzled designers at Bendix Aviation's Bendix Products Div.-Missiles, in Mishawaka, Ind.

Bungee cords were tried, but they were too bulky and pulled too hard on the cables when the chassis were fully withdrawn. Counterweights avoided the problem of force build-up, but they were too susceptible to shock and movement. Bendix engineers even considered coiling a long helical extension spring right into the cable proper, but this proved impractical.

The final solution was effective and simple. They mounted a small Neg'ator B spring motor at the bottom rear of the console cabinet and connected its stranded steel output cord to the electrical cables with a Teflon line.

When a chassis is returned to the cabinet, the spring motor pulls the cables back and down into the three-inch [illegible] back of the cabi[illegible]

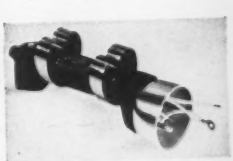
[illegible]ause of the con[illegible] exerts a constant [illegible]through a pulley [illegible]he motor output [illegible]an 10 per cent [illegible]0 to 4 ft. [illegible]ard products of [illegible]Pa. The motors [illegible]up spool, upon [illegible]re mounted on [illegible]ase. The cord [illegible]spool. [illegible]e charges the [illegible]spring on the [illegible]alley cable is [illegible]naller take-up. [illegible]th the pulley [illegible]ors mounted [illegible] cross-piece. [illegible]en the wire [illegible]trical cables [illegible]tle slack in

· DESIGN NEWS

Constant-Torque Spring Motors

Two constant-torque motors have been developed for use in designing mechanisms using this spring motor. They can also be used in applications requiring light tension forces through long deflections. The new motors have the same standard bases and use the same combination of standard mounting drums as the earlier B motor models. Both are 3.75 inches long, 2.5 inches wide and 1.20 inch high. The Model A-2025-1 exerts one-pound tension on the stainless steel output cable throughout its six-foot extension. Model A-2025-2 exerts two-pound tension throughout the same cable extension. Length of [illegible] cable extension for each motor can be [illegible] [illegible] inches and 9 ft. 7 inches, respec[illegible] [illegible] lower capacity motor [illegible]

· MILL & FACTORY



Simple, one-piece, constant-force clamps . . .

Speed Assembly Cementing Operation

Problem: Speed and simplicity are primary requisites of any mass production assembly operation. Both these requirements [illegible] at General Elec-

Solution: Now at General Electric two Neg'ator clamps hold the skillet handle and its cover together while the adhesive dries. Each clamp is a Neg'ator con-

slight variation of the company's stock clamps, both ends of which have been allowed to coil separately. The clamping pressure between the two loops remains constant at any clamp opening.

Simple to use, an ideal for clamping odd-shaped as well as regular parts, the clamps are easily opened and slipped around the skillet handle by simply spreading the loops. When released, the coils immediately adjust themselves, and continue to do so as the cement dries. Each coil provides a positive clamping pressure of 5 lb throughout the drying cycle.

Source: Hunter Spring Co., Dept. MF, Lansdale, Pa.

PUBLISHED BY HUNTER SPRING COMPANY • LANSDALE, PENNSYLVANIA
A Division of American Machine and Metals, Inc.

For an additional copy of this sketchbook Circle 462 on Page 19

· PURCHASING NEWS

Timely Tips on Buying

NEG'ATOR Springs—

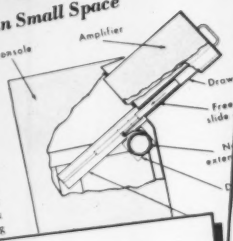
Positive Force in Small Space

The Neg'ator spring, Hunter Spring Co.'s trademark for its constant force springs, represents a new solution to unusual spring problems. Hundreds of successful applications have proven the soundness of the idea. Its possibilities have yet to be fully realized.

"The Neg'ator Spring motor has been the ticket for elimination of counterweights in our automatic tank gages," states P. C. Jurs, V. P., Mechanical Products Div., Shand and Jurs Co., Berkeley, Calif. "Before we started to use these motors several years ago, we employed a mechanism with counterweights for its constant force requirements. Now we use a Neg'ator spring motor which is compensated slightly for the increase in diameter of the tape roll as more tape is rolled up, and for the decrease in weight of tape in the tank as the float rises.

"We have had no failures due to normal service so far," continues Mr. Jurs. "Fatigue life is rated at 15,000 cycles, minimum, which should be enough for approximately twenty years. However, precautions are required against breakage, such as might occur if the motor should accidentally be unloaded and run wild, as considerable energy may be suddenly released."

The basic Neg'ator spring is a simple device resembling a roll of metal tape. During its extension, the force required remains unchanged in all positions. It



· DESIGN NEWS

NEW DESIGN IDEAS

Increasing Spring

No. 89

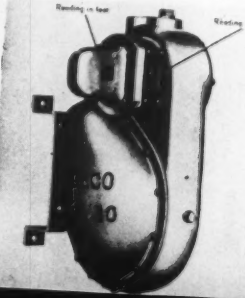
Designing a "Negator" spring with an increasing deflection rate provides a means for compensating and balancing the weight of a long length of stainless steel tape in this tank gage. The tape connects a float and indicating device. It varies in length as much as 70 feet. A portion of weight due to this variation in length would have to be carried by float if it were not compensated for in the spring arrangement.

Spring and float tape are anchored to a common primary drum unit. Two strips are reverse-wound on the drum. A secondary idler drum provides spring storage.

One advantage of this design is that the same basic mechanism can be installed in any position. An inverted installation requires that the ½ inch wide stainless steel tape be threaded through a 180 degree direction change by a pair of idler sheaves. For underground installations, unit can be installed directly in line with vertical float travel.

A small error in spacing of 5/32 inch diameter holes on 1 inch centers would have a large cumulative effect on 70 feet of tape. Holes in the tape are gang-punched. This method reduces cumulative error directly by the number of punches in the gang die. The tank gage is a design of the Johnston & Jennings Co., Div. of Pettibone Mulliken Corp., Chicago, Ill.

TANK GAGE operates in either of two positions vertical directly over float or inverted with two sheaves to reverse direction of stainless steel tape. Unit senses level changes up to a maximum of 70 feet. Float is attached to an 0.005 inch thick stainless steel tape with 5/32 inch diameter holes on 1 inch centers.



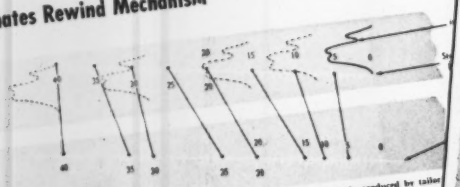
· DESIGN NEWS

NEW DESIGN IDEAS

Compensator's Spring-Steel Dial Eliminates Rewind Mechanism

A spring steel dial, its ends naturally wrapping around two posts, apply opposed torques against the teeth of two common-driven sprockets. Because the exposed section of the dial is pulled tight, it not only remains flat but the sprocket teeth always contact the tape drive rolls. This reduces error-producing backlash and eliminates rewind machanism.

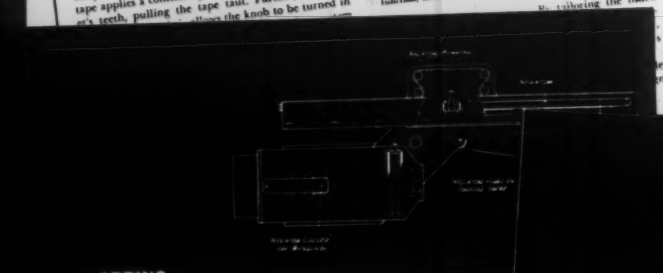
The self-coiling spring-steel tape is threaded like movie film from one winder post around the sprockets and on to the second winding post. As it passes between the sprockets, the scale can be viewed through a small window. A knob-driven shaft rotates a common gear, driving the two sprockets so that they move the tape together. Because the spring-steel tape attempts to wind itself around posts at both ends, the tape applies a constant spring load against the sprocket's teeth, pulling the tape taut. Further, the same



TAPE moves behind index in actual instrument. Index is easily inscribed to cover individual conditions. Wide variety of applications may be covered by one type of linear scale. Example shows typical non-linear index and straight line scale. In example, Fig. 1 is standard linear tape. To cover a certain function, distorted scale as in Fig. 2 would be required. Lower non-linear base is effectively produced by tailor illustration. Illustration shows effect incurred. A linear scale moves under non-linear index. In setting control knob to desired point, then window face at this spot. Process is repeated Points are connected, producing calibrating

By tailoring the index

objective, there remained the comb and backlash problem. The windup matter of operating convenience. Th be minimized if the scale/index lin to remain fixed. The use of the coile solved both problems for General C Boston, Mass.

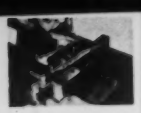


SPRING

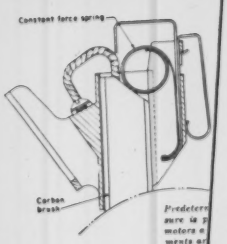
Long deflection and constant force offered by the Neg'ator have made it possible to simplify the design of many mechanisms. For example the ratio mechanism in the contour wheel dresser (above and right), made by Hoglund Engineering and Manufacturing Co., Inc., uses two opposing Neg'ators to maintain optimum constant contact pressure on the contour-cam follower. Helical springs cannot be used because they would be too difficult to match and would not exert constant forces through most of the follower path.

Longer brush life and commutation efficiency in electric motors depends upon brush contact pressure. Neg'ators are used in the brush holders of the General Electric Kinamatic dc motor (right) to maintain a predetermined and constant pressure throughout brush life. The use of this type of brush holder eliminates periodic manual brush pressure adjustments and also simplifies the assembly, which makes brush removal and replacement easy and requires no tools.

Each vertical column of shelves in the vending machine on the right (bottom) has a Neg'ator that exerts two pounds of pressure at any point on the elevator assembly from the bottom to the top of a notched channel. Here again, the Neg'ator's constant force



Two opposing contact pressure lower in the tour wheel dr



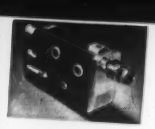
Predetermure is p motors a ments ar

MOTOR

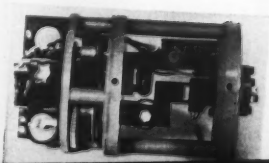
The Neg'ator supplies constant torque—the primary reason behind its use in the applications on this page. The Eastman Kodak 16 mm. Cine-Kodak K-100 (above and right) was the first production motion picture camera to use a Neg'ator in place of a conventional power spring. The result was longer film footage per wind (40 feet or 100 seconds of exposure at 16 frames per second) without taking up any more space. Constant torque eliminated the inconsistent output—peak at full wind, and low torque at near rundown—experienced with conventional spiral springs, and made it possible to simplify gearing and governor design.

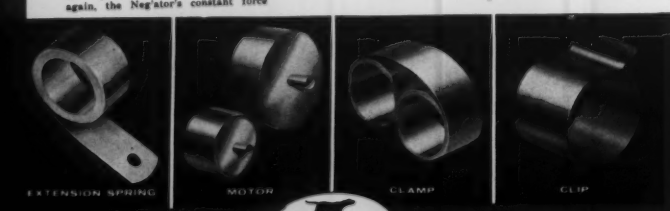
Compactness and ruggedness were additional considerations that prompted the specification of a Neg'ator as a chart drive motor in the tensiometer (right), developed to record the duration, frequency and magnitude of transient forces exerted by a parachute on its load during deployment and deceleration. A constant-speed motor was

Eastman Kodak's K-100 achieves longer film footage per wind, simpler gearing and governor assemblies, by using a Neg'ator motor in place of a conventional spring.



Tensiometer used to record forces exerted by a parachute on its load takes advantage of the Neg'ator's ability to resist impact, by using one as a chart drive motor.





HUNTER

HUNTER SPRING COMPANY

A Division of American Machine and Metals, Inc.

29 Spring Avenue, Lansdale, Pennsylvania

SPRINGS • STAMPINGS • QUALITY CONTROL EQUIPMENT

For an additional copy of this sheet, Circle 443 on Page 19

Printed in U.S.A.

When it's time to pick the best friction materials for your latest clutch or brake design

The J-M Friction Specialist is a good man to have at your side!

No one friction material can possibly handle all motion control needs. That explains the wide latitude the J-M product line offers you when it's time to select frictions to suit *your* design.

Johns-Manville has developed a range of frictions to meet almost any requirement. Each piece can be depended on to give the sort of performance expected in well-designed equipment. And experienced J-M Representatives and extensive J-M research facilities are ready to help you select the most effective and economical material. Where miniaturization is a factor . . . in wet or dry operations . . . J-M Frictions can be ordered as small, integrally molded precision parts. J-M Small Molded Parts can also be compounded for anti-friction needs such as rotary seals, bushings or bearings. Now—before you get to work on that new design—is a good time to consult your J-M Friction Specialist.

For your free copy of the J-M Industrial Friction Materials Guide, giving recommendations, design and operational data on all J-M friction types and styles, write Johns-Manville, Box 14, New York 16, N.Y. In Canada: Port Credit, Ontario. Ask for FM-35A.

JOHNS-MANVILLE

JOHNS-MANVILLE JM PRODUCTS

Circle 463 on Page 19

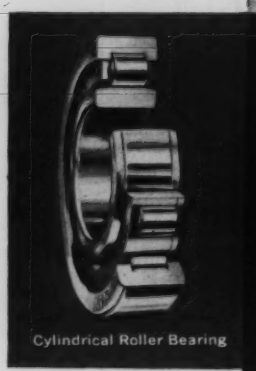
What qualities should a "production" bearing have?

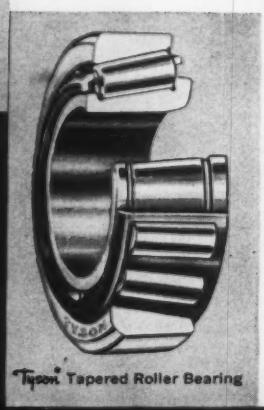
Take a single-row deep-groove bearing, for example.

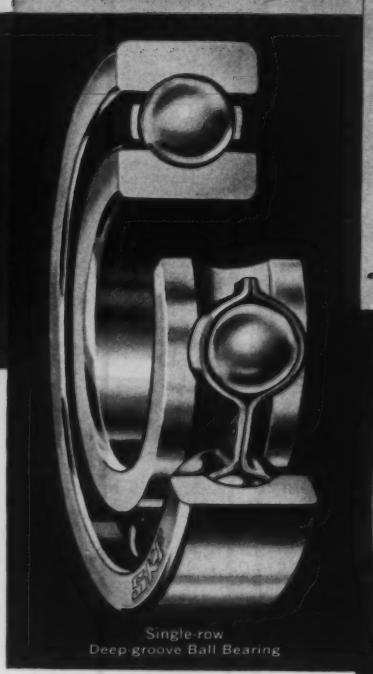
As SKF makes it, the type shown here sustains heavy radial load—as well as thrust load in either direction—it can be used at normal speeds with grease lubrication or at high speeds with oil. *Yet it is a standard SKF bearing.*

We even mass-produce some sizes of this particular bearing at our automated Altoona (Pa.) plant. You can buy quickly and economically. There are over 100 sizes ranging from over ⅝" O.D. to almost 16" O.D., with various seal, shield and snap-ring combinations.

But why not compare the quality, availability and price of this SKF bearing (or any of the other SKF products) with those you now use? For details, just call any of the 25 SKF sales offices. 5916







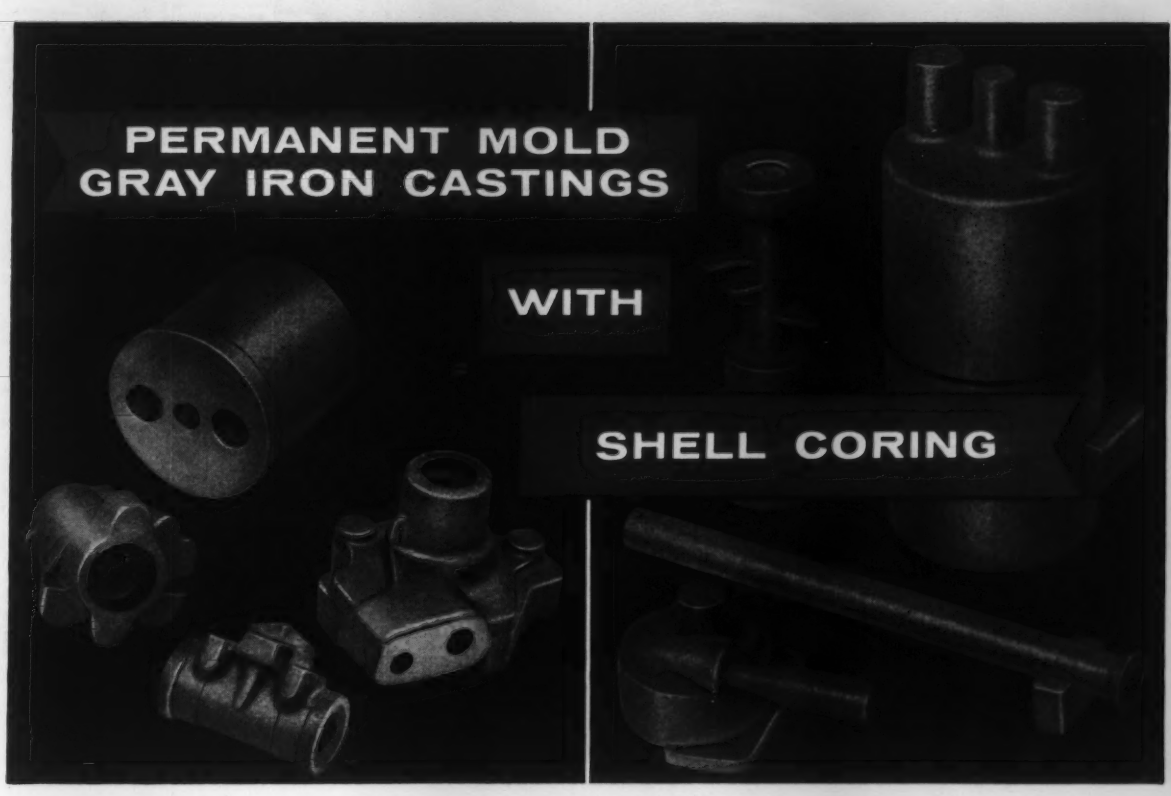
Spherical, Cylindrical, Ball, and Tyson Tapered Roller Bearings

EVERY TYPE—EVERY USE

SKF®

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.

*REG. U. S. PAT. OFF.



RESULT: Better Finish at Lower Cost

In addition to the long recognized advantages of Eaton Permanent Mold Gray Iron Castings, the use of shell coring gives an even greater uniformity of structure and an improvement in internal surface finish. This results in machining economy and fewer rejections, which, in the end, mean lower cost of finished parts.

If you have applications where more than ordinary quality is required, Eaton Permanent Mold Gray Iron Castings offer many advantages. Whatever your requirements, our engineers will be happy to work with you.

Send for Illustrated Descriptive Literature

Consider these Important Advantages

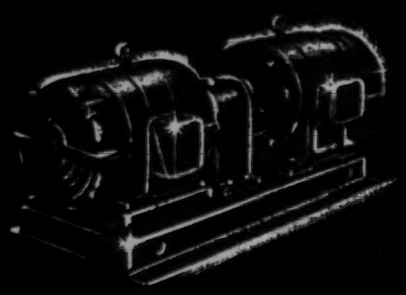
- ★ Intricately cored sections
- ★ Uniformity of castings
- ★ Higher machining feeds and speeds
- ★ Substantially increased tool life
- ★ Dense, non-porous, homogeneous structure
- ★ Freedom from inclusions
- ★ Excellent tensile strength
- ★ Ability to take high surface finishes
- ★ Freedom from leakage under pressure

EATON

FOUNDRY DIVISION
MANUFACTURING COMPANY
VASSAR, MICHIGAN

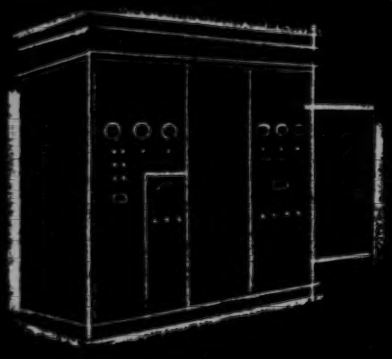
Circle 465 on Page 19

1 Precise high-frequency drives for generators or converters



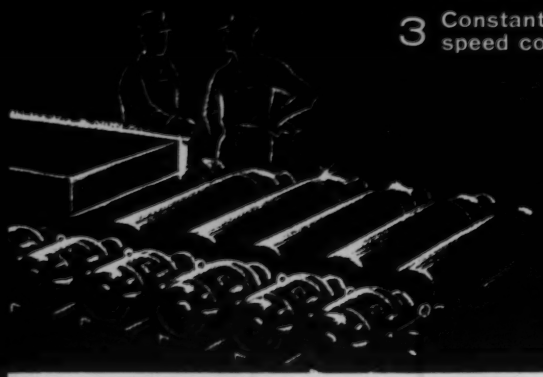
Because of its exact speed characteristic, the Syncro-Spede is an ideal driver for high-frequency generator sets where precise frequency is a necessity. The elimination of slip provides exact frequency throughout the entire load range of the motor.

2 Precise timing, metering, and recording devices



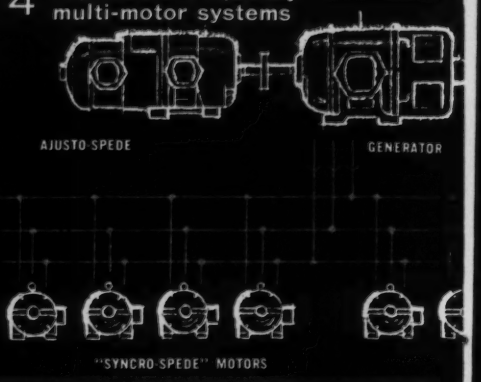
Syncro-Spede delivers and maintains exact synchronous speed within rated capacity regardless of load or line voltage dips. Its design permits mechanical modifications to meet special needs. Since it eliminates error caused by speed fluctuations, this new Louis Allis motor is also ideal for memory drums and precision timing devices.

3 Constant single- or multi-speed conveyor drives

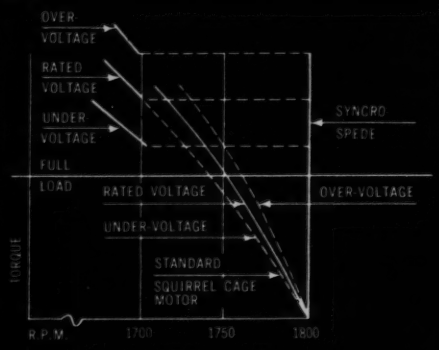


Syncro-Spede gearmotors can provide exact constant conveyor speed — or maintain correct relation of several conveyors operating at different speeds. Used with Louis Allis gear drives, the Syncro-Spede offers a practical, low-cost solution to low-speed conveyor drive requirements —down to 7.5 rpm.

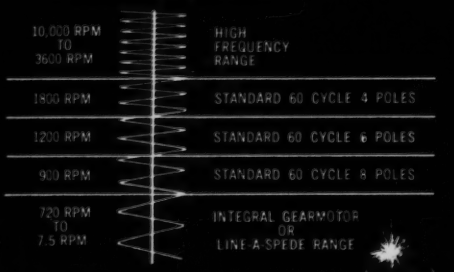
4 Adjustable frequency multi-motor systems



5 Any constant speed requirement



6 High speed — high frequency operation



Below values are typical values based upon 100% pull-in torque with the external inertia equal to no more than twice the rotor inertia. To obtain full load and locked amps for other standard low voltages, multiply below 220 volt values by the inverse ratio of the voltages. For applications with high external inertias, refer to factory with specific inertia values.

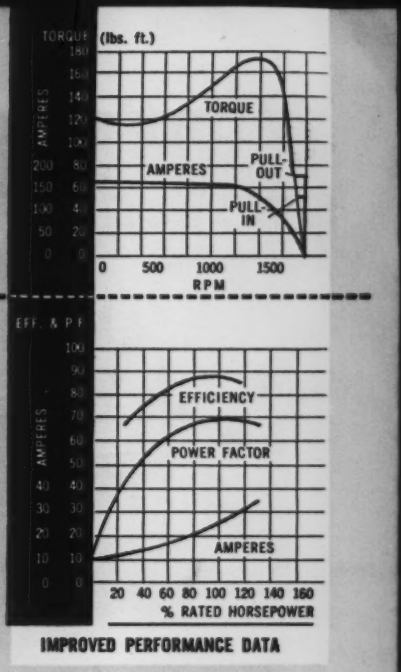
HP	Synch. RPM	Frame Size	Full Load Amps 220 V.	% Locked Rotor Torque	Locked Amps 220 V.	Full Load Power Factor	Full Load Efficiency	Rotor WK²
1	1800	182	4.4	275	30	59	76	.18
	1200	184	4.6	200	30	58	75	.22
1.5	1800	184	6.6	265	41	59	76	.18
	1200	184	7.0	200	41	58	75	.24
2	1800	184	7.7	250	58	64	82	.22
	1200	213	8.3	200	58	62	78	.49
3	1800	213	11	250	83	67	82	.49
	1200	215	14	200	83	61	78	.80
5	1800	215	17	200	120	68	85	.80
	1200	254U	21	175	120	61	82	1.30
7.5	1800	254U	25	200	170	68	86	1.30
	1200	256U	28	175	170	62	83	1.80
10	1800	256U	34	200	240	68	85	1.80
	1200	284U	36	175	240	63	83	3.50
15	1800	284U	49	200	330	70	86	3.0
	1200	326U	54	165	330	63	84	5.50
20	1800	286U	63	200	420	70	87	5.00
	1200	326U	65	150	420	64	85	5.50
25	1800	324U	79	200	520	70	87	6.0
30	1800	326U	95	200	700	70	88	7.0

Syncro-Spede motors of different ratings and output speeds can be synchronized from a single adjustable frequency source — motors of various speeds will hold their exact relationship within an operating frequency range of 5 to 1,000 cycles. This combination provides precise adjustable frequency power for many applications in the printing, paper, plastic, and textile industries.

The Syncro-Spede offers virtually unlimited usage. It is much smaller than equivalent reluctance and DC excited synchronous motors—outperforms both and costs less. Under full load conditions, a standard squirrel cage induction motor may vary between 1740 and 1760 rpm with a 10% voltage variation — the Syncro-Spede maintains exact synchronous speed.

Syncro-Spede's indestructible cast aluminum rotor is designed for high-speed — high frequency operation. The small diameter rotor enables the motor to attain speeds previously impossible with other types of synchronous motors. With special rotor designs, the Syncro-Spede can reach speeds of 10,000 rpm and higher.

New-product news from Louis Allis



IMPROVED PERFORMANCE DATA

The Louis Allis Syncro-Spede

...a synchronous motor built in the same NEMA frames as standard motors of equal horsepower!

It's compact, simple, versatile...and trouble-free!

The remarkable Louis Allis Syncro-Spede® Motor enables you to provide exact synchronous speed for *any* application for less cost — with fewer controls — and in less space than previously possible.

If your equipment or operation calls for precise constant speed, check the advantages this new motor offers you:

***Space-saving design* — The revolutionary Syncro-Spede needs no external excitation, wound rotating fields, collector rings or brushes. It's built in the same standard NEMA frames as ordinary induction motors of equal horsepower. It requires less space — is virtually maintenance-free.**

***Wide range of enclosures* — The Syncro-Spede can be provided in a wide variety of enclosures to meet special operating requirements. For example, Syncro-Spede is readily available in totally-enclosed fan-cooled and explosion proof enclosures — thus permitting installations which were difficult to make with D.C. excited synchronous motors.**

***Unmatched versatility* — Syncro-Spede is available in standard sizes up to 100 hp, and even larger ratings for special applications. It can also be furnished in a wide range of mechanical modifications . . . base- or flange-mounted — as a gearmotor or brakemotor — even as a rolled-shell shaftless motor for "built-in" applications.**

For full particulars and expert application engineering help, contact your local Louis Allis District Office. Or write for Bulletin No. 1900 to The Louis Allis Co., 459 East Stewart Street, Milwaukee 1, Wisconsin.

Syncro-Spede is a Trademark of The Louis Allis Company

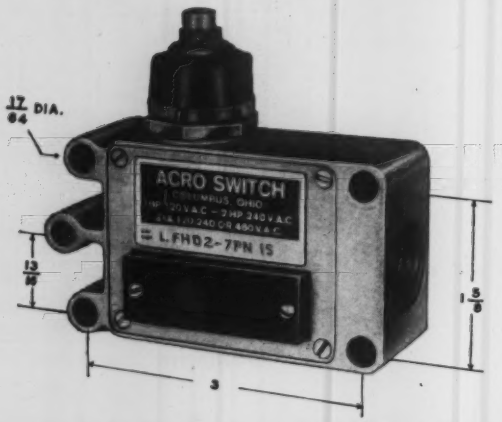
MANUFACTURER OF ELECTRIC MOTORS AND ADJUSTABLE SPEED DRIVES

LOUIS ALLIS

LA-340

Circle 466 on Page 19

What's new in Acro's metal-clad switches? *It's Acro Lite.....with a Visual Indicator Directly on the Switch!*



This year — Acro's 20th — introduces ACRO-LITE — a brand new feature that gives your customers visual evidence of performance — directly on the switch! If you specify metal-clad switches in your product line, direct your purchase inquiry to Acro Switch. For Acro makes a complete, reliable line of metal-enclosed switches — that fill your needs for protective housings, with either side or flange mount casings.

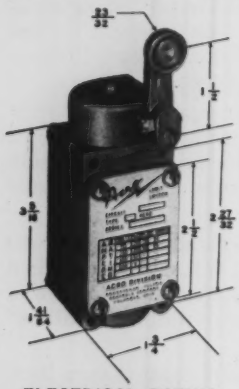
When Acro-Lite is Lit – the Switch is Powered!

This visual indicator panel consists of a neon light, built directly into the side of the switch. When the light is on, there's power flowing through the switch. Or, if your product construction hides the switch from direct view — the light can be mounted remotely for easy visibility. Acro-lite offers high current ratings — 21 Amps — up to 2 HP.
Switching unit completely enclosed in sturdy, lightweight aluminum. Rubber gaskets on all removable parts of the housing. Neoprene boot seals the overtravel plunger, making the switch dust - and splash-proof; assures continuity of repetition patterns. Connecting conduit (switch housing is internally tapped for ½" conduit) completes the seal. Light operating pressures, with close movement differential.

NEW! **Acro's "20th Anniversary" Acro-Lite Acts as a VISUAL INDICATOR on the Switch!**

FEATURES:
- Switching unit is replaceable without removing housing from its mounting
- Choice of five different actuators
- Mounting is optional through any of the five mounting holes provided
- Contact arrangement: single pole double throw. Internal switch has screw terminals
- High capacity. Internal switch U.L. approved for 21 amperes at 120, 240, and 480 V.A.C. Also approved 1 HP-115 V.A.C., 2 HP-240 V.A.C.

Acro's Small Sized Machine Tool Switch Handles Heavy Load



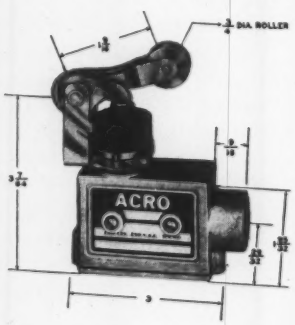
Controls up to four separate circuits for either pilot or line duty. Perfect for machine tool and all production machinery applications. Actuator is adjustable 360° in two planes. Basic switch is easily replaced. Dust-and oil-tight, long mechanical life, long overtravel. Meets NEMA and JIC requirements.

Available in Two Types

Double Action Type actuates switch contacts when actuator is moved either side of "at rest" position. Single Action Type operates from one side of "at rest" position only. Both designed for long life under heavy use.

ELECTRICAL RATING
2 H.P. 230 Volts A.C.
1 H.P. 115 Volts A.C.
20 Amps-250 Volts A.C.

Acro's Model "F" Enclosed Switches Have Exceptionally High Capacity



Acro features a complete line of enclosed switches with many different actuators and styles available. Dust and oil type enclosure, with side or flange mounting. Replacement switch kit is available.

Underwriters Laboratory approved

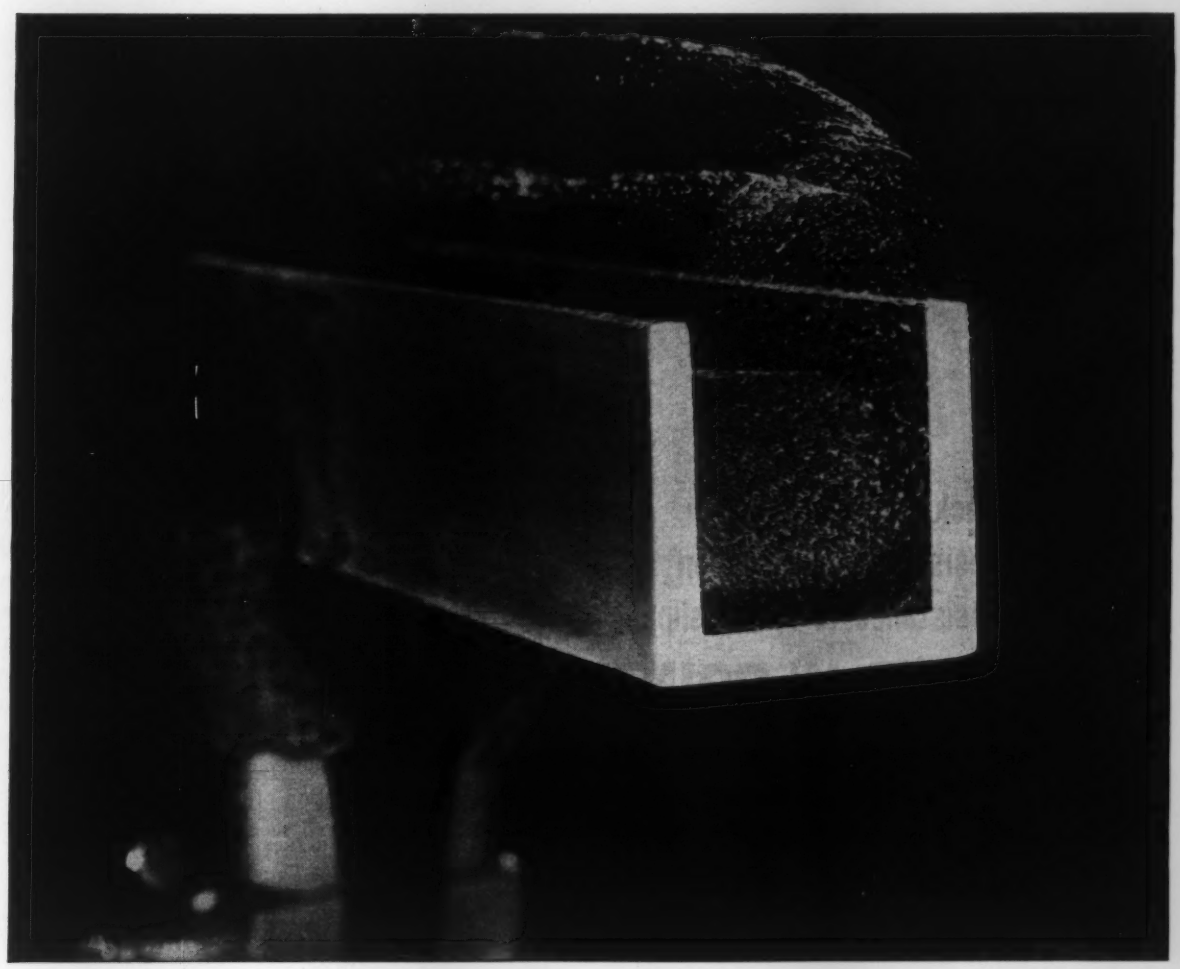
Write for more detailed information on ACRO's metal enclosed switches and take advantage of our free engineering service. We'll be happy to go to work on your specific application problem. District offices located in principal cities.

HIGH ELECTRICAL RATING
2 H.P. 240 V.A.C.
1 H.P. 115 V.A.C.
21 Amps @ 120, 240 or 480 V.A.C.

RELAYS ACRO SWITCHES

"OUR 20th YEAR"

ACRO DIVISION Robertshaw-Fulton CONTROLS CO.
COLUMBUS 16, OHIO
Manufacturers of a complete line of load-tested precision snap-switches and relays.



Seal even irregular gaps and seams with

3M HEAT EXPANDABLE SEALERS

TIGHTER, TIGHTER, TIGHTER grow seals of unique 3M Heat Expandable Sealers. Expanding up to 125% under the normal heat of a paint-baking cycle, they cure to a tough, flexible mass that *really* keeps out dirt, water and weather . . . that *completely* seals even the most irregular gap or seam.

In either *liquid* or *extruded bead* form, 3M Heat Expandable Sealers help you save time and cut costs, too. Simply flow in the liquid or lay in the extruded solid by hand. There's no material waste, no cleanup time involved. And because no solvent is present, there's no danger of toxicity or fire.

The unexpanded solid is also efficient as a gasket replacement sealer, flange sealer and for other sealing jobs. It's tacky enough to stay in a vertical or overhead seam. Yet, it can be easily removed. Proper positioning is never a problem. Investigate versatile 3M Heat Expandable Sealers now.

SEE WHAT 3M ADHESIVES CAN DO FOR YOU!

Contact your 3M Field Engineer. Or, for more information, write on your company letterhead, stating your area of interest, to: A.C.&S. Division, 3M, Dept. SAR-99, St. Paul 6, Minnesota.

ADHESIVES, COATINGS AND SEALERS DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY

. . . WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

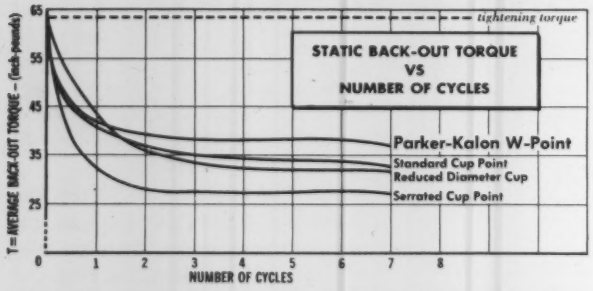
Another new fastener idea from Parker-Kalon

30% more back-out torque
50% more resistance to vibration
50% more resistance to rotary slippage
with the New P-K® W-POINT SOCKET SET SCREW

NOW YOU CAN OBTAIN THE HIGHEST DEGREE OF HOLDING POWER EVER ATTAINED

30% MORE BACK-OUT TORQUE

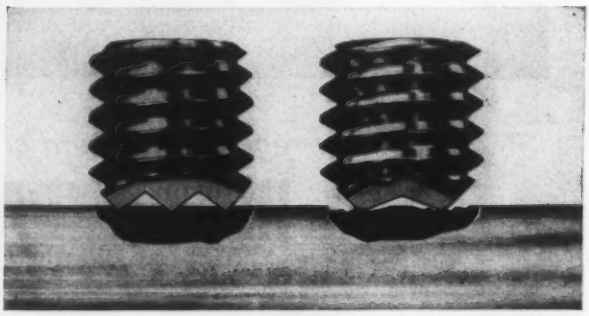
In a series of tests, performance of the new P-K *W-Point* was matched against that of small cup, serrated cup and standard A.S.A. cup point screws. A number of blocks and shafts were matched to precision tolerances for each of



the four set screws under observation. Again and again each screw was tightened on a new portion of the shaft, the screws loosened and the back-out torque recorded. Results were consistent and conclusive. In every test there was less decay in back-out torque for the new *W-Point* than for any of the other three types.

50% MORE RESISTANCE TO VIBRATION

In all tests under normal conditions of vibration, the other three types of set screws loosened and rapidly lost their holding power. Examination to determine the cause showed that with all other screws, final tightening caused them to deviate from the axial line through the center of the screw which in turn caused uneven tracking. The tests indicated that unless the cup point forms a true track in the shaft, vibration will result in loosening within a very short period of time. At the conclusion of each test run, the new P-K *W-Point* was still seated securely and in tight frictional contact with the shaft.

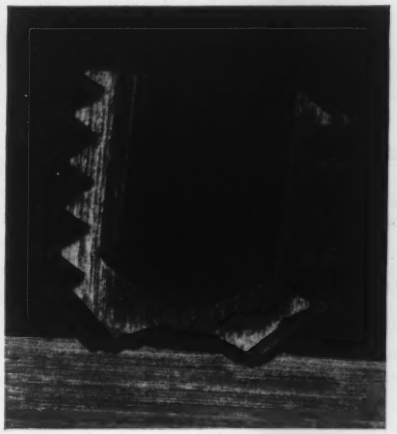


50% MORE RESISTANCE TO ROTARY SLIPPAGE

W-Point set screws, small cup, serrated cup and standard A.S.A. cup point screws were test-matched on various types and sizes of shafts at rest, in motion, and in start-and-stop operation. Examination of the impressions left on the work showed that all other types of cup point set screws when tightened, created tracks which are uneven in depth and shape. Impressions made by the new *W-Point* were perfectly circular and even in depth at all points on the circumference. There was also clear evidence of rotary slippage by the other cup point screws while the sharp pivot point of the *W-Point* Set Screw effectively prevented such slippage.

WOBBLE AND TIPPING CONTROL

Users of cup point set screws have long recognized two problems directly related to the proper seating of the screw on the work . . . "*wobble*" and "*tipping*". Until now, "wobble" could not be avoided because of the tolerance clearance which must be provided between screw threads and the tapped hole. In addition, users of conventional cup point set screws are aware of the fact that the key itself imparts a tipping movement to the screw during the tightening operation. The result of these two factors often results in a weakening of holding power. Upon completion of the torquing of a conventional cup point set screw, only a part of the flank of the cup edge remains in frictional contact with the work. The guidance provided by the carefully engineered construction of the new P-K W-Point, reduces "wobble" and "tipping" to an absolute minimum—results in true circular tracking by the cup edge with flanks in intimate frictional contact with the work. With "wobble" and "tipping" eliminated, the *increased contact areas* PLUS the *new pivot point* PLUS Parker-Kalon's uniformly finished Class 3A "*ground thread*" quality feature, provides the revolutionary W-Point with an inherent resistance to loosening . . . *a frictional grip superior to any type of cup point socket set screw now in use!*



TEST THE NEW W-POINT FOR YOURSELF

You are cordially invited to examine and test the new P-K W-Point socket set screw in your own plant. When you do, notice its precision manufacture, its perfectly finished ground threads, the well-defined last full thread. Like many important advances in technology, the W-Point concept is simple and straightforward. In use, its superior performance and holding power will be demonstrated to your own satisfaction.

NO INCREASE IN COST

You get all the advantages of this revolutionary improvement in socket set screws *at no increase in price!* The W-Point is available in #4 to 1" diameters in Alloy, and #4 to ½" diameters in Stainless Steel . . . stocked in popular sizes. Other sizes made to order. Approved, Military Standards, 51017 through 51024.

FOR SAMPLES AND COMPLETE TECHNICAL DATA, CALL YOUR P-K INDUSTRIAL DISTRIBUTOR, OR WRITE DIRECT TO P-K FOR BULLETIN NO. 1106

Look to Parker-Kalon for quality Socket Set Screws, Cap Screws, Shoulder Screws, Button Head and Flat Head Socket Screws, Pipe Plugs and Dowel Pins . . . the most complete line in the industry. PARKER-KALON, a division of General American Transportation Corporation, Clifton, New Jersey. Offices and warehouses in Chicago and Los Angeles.

PARKER-KALON

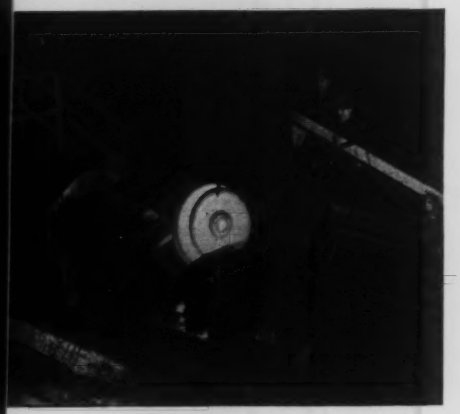
W-Point Socket Set Screws*

*Patent Pending

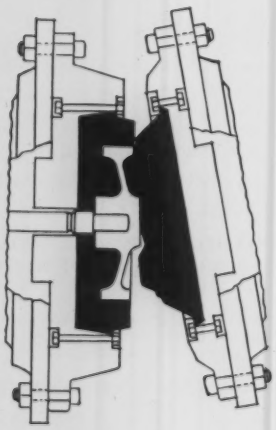
Circle 469 on Page 19

Unique Mill Forges and Rolls circular products in one operation

In less than one minute, this Bethlehem mill—the only one of its kind in the country —turns out a top-quality impression-die steel forging at a cost that's hard to match.



This is Bethlehem's famed circular-products mill—the Slick Mill. Named for its designer, Edwin E. Slick, this unique machine produces impression-die circular forgings ranging from 10 in. to 46 in. OD; as-rolled weights ranging from 100 to 2,000 lb. It handles almost any grade of steel—carbon, alloy or stainless, as well as certain heat-resistant grades.

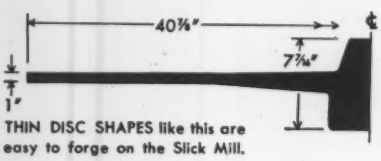


How It Works

Designed to operate in a horizontal plane, Bethlehem's Slick Mill is constructed with two *revolvable* spindles on which face plates are mounted. These face plates support the impression dies that form the steel billet into shape by a combination press and rolling action.

After the steel billet is heated and descaled, it is centered between the dies of the Slick Mill. Then a 1500-ton hydraulic ram actuates the spindle on the straight side of the mill, upset forging the billet. When this cycle is completed, a 2,000-hp motor actuates the spindle on the angle side of the mill and the rolling cycle begins. By continuing the upsetting action and rotation of the dies and work, the material flows into the recesses of the dies, resulting in the desired shape. *The entire rolling cycle takes about one minute.*

After rolling, excess material in the form of flash is sheared off; the hub, when necessary, is punched; and the forging is inspected.



THIN DISC SHAPES like this are easy to forge on the Slick Mill.

Cost-Saving Features

Quick operation: Only one minute is needed to convert a heated slug into a contoured forging, whether the product weighs 100 or 2,000 lb.

Quick die changes: Only 15 minutes are needed to change and set up dies. Even production runs as small as 25 or 50 pieces are economical.

Low die charges: Since contact time between die and work is very brief, and because there is no impacting, low-cost die blocks can be used. In many cases, die charges are ⅓ to ½ less than conventional impression dies.

Less steel needed: Utilizing the principle of forging design, the Slick Mill can produce lighter-weight sections without sacrificing strength.

Good physical characteristics: The process insures excellent grain flow, machinability and soundness.

Bethlehem's Slick Mill is readily adapted to jobbing or production quantities of forged circular products such as: gear blanks, fly wheels; crane track wheels; sheave wheels; brake drums; clutch discs; couplings; tire moulds; and turbine or compressor wheels. Products may be specified as-rolled or rough machined to specifications.

Your inquiry—whatever the quantity involved—will receive prompt attention. Call or write the Bethlehem sales office nearest you today.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

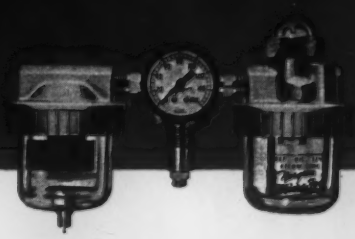
Circle 470 on Page 19

Where Space is Tight...

NEW SPACE SAVING

Norgren MICRO-FOG

Lubro-Control Units



Models Available for Air Flows from .05 to 20 cfm.

These new Norgren MICRO-FOG units: **1.** Provide highly efficient compressed air processing for air tools and other air operated devices. **2.** Provide efficient lubrication for bearings and machine tool components. Maximum operating pressure 150 psi, maximum temperature 120° F.

AIR LINE FILTERS

Two new air line filters provide efficient removal of liquids and solids from the air line, preventing damage to connected air equipment.

PRESSURE REGULATOR

A new small, compact pressure regulator is used for both series of Lubro-Control Units. It provides accurate, trouble-free regulation of the air pressure. Adjustable over a pressure range of 5 to 100 psi.

MICRO-FOG LUBRICATORS

New MICRO-FOG Lubricators provide efficient and adjustable lubrication for bearings, air tools, air cylinders and other air operated devices.

If it's Norgren... It's Dependable.

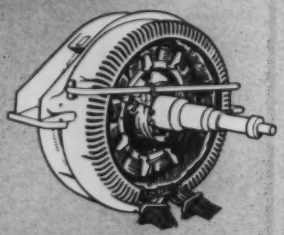
For complete information, call your nearby Norgren Representative listed in your phone directory, or WRITE for BROCHURE No. 915B

G. A. NORGREN CO.

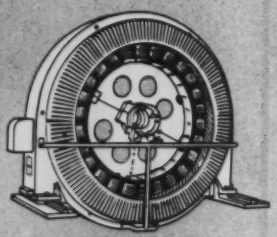
3442 SOUTH ELATI STREET, ENGLEWOOD, COLORADO

Circle 471 on Page 19

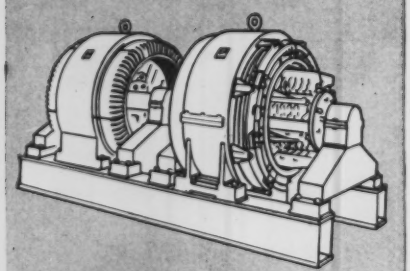
MATCHED-TO-THE-JOB PERFORMANCE
assured by
EP SPECIALIZATION



SYNCHRONOUS GENERATORS
125-5000 KVA
ASK FOR BULLETIN 43-205

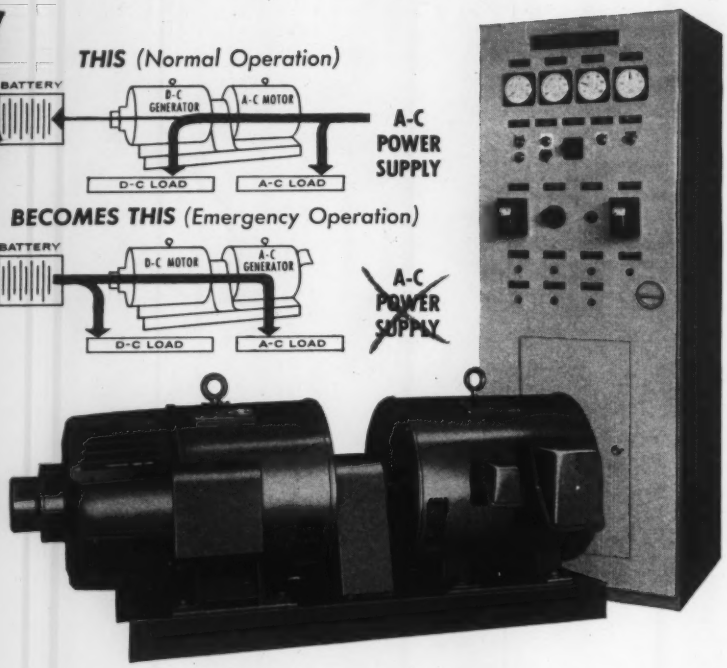


SYNCHRONOUS MOTORS
20-5000 HP
ASK FOR BULLETIN 43-205



MOTOR-GENERATORS
¾-1500 KW
ASK FOR BULLETIN 30-200

also
ELECTROLYTIC POWER SUPPLIES
FREQUENCY CHANGERS
INDUCTION MOTORS
D-C MOTORS & GENERATORS
ADJUSTABLE-SPEED DRIVES



Inverter-Diverter

THE ONLY CONTINUOUS A-C and D-C POWER SYSTEM

This standby Power System changes from normal operation to emergency operation (when the normal a-c power supply is interrupted for any reason) without any appreciable change of voltage or frequency of the load current. The changeover is instantaneous. It is ideally suited for any application where *UNINTERRUPTED* electrical service for either or both a-c and d-c loads is required.

Only *one* motor-generator set is used as a combined battery charger, d-c power supply and a-c standby power. Note, from the diagrams above, how the D-C Generator and A-C Motor "invert" for emergency operation. And the D-C Generator is the well-known Electric Products DIVERTER-POLE with its unequalled battery-charging characteristics.

The Inverter-Diverter requires less space, reduces installation time and expense, cuts maintenance costs and provides absolute dependability. For complete details:

ASK FOR BULLETIN 21-200

EP ENGINEERS A TYPE OF CONTINUOUS A-C AND D-C POWER SYSTEM TO MEET THE SPECIFIC APPLICATION REQUIREMENTS

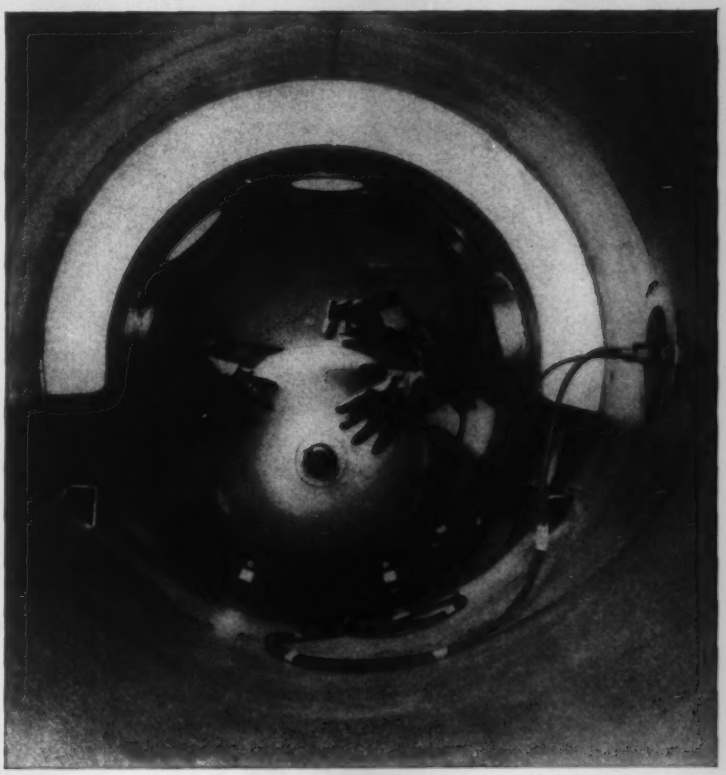
ELECTRIC PRODUCTS COMPANY
1725 CLARKSTONE ROAD CLEVELAND 12, OHIO
EP

HAYNES ALLOYS

RESEARCH REPORTS

Developing new metals and improving current ones to combat the devastating effects of high heat, corrosion, erosion, and abrasion, are the primary objectives of the advanced Research and Development Laboratories at Haynes Stellite Company. HAYNES Tantalum, described below, is one of their more recent achievements. Others will be described in future Research Reports.

Design engineers, metallurgists, and physicists may see in these new metals and alloys opportunities for a breakthrough in applications where limited properties of other metals have presented obstacles. Our research scientists, engineers, and technicians will gladly help you discover whether they can help improve your products.



HAYNES Tantalum

Close to 100% pure, chemically. It is produced by the consumable-electrode process. Practically inert to a wide variety of corrosive media, with these added advantages: *Wide* sheets with improved welding characteristics, making it easier to use in chemical and pharmaceutical equipment where corrosion and product contamination must be minimum. Pictured is tantalum reactor liner being welded inside tank of inert gas.

LARGEST Tantalum Lined Reactor

An outstanding example of what can be accomplished with the greater sheet width and improved welding characteristics of HAYNES Tantalum is shown above. The vessel—the largest tantalum-lined reactor ever constructed—is a 30-gallon unit designed to operate at 630 deg. F. and 500 psi. Every part that will be exposed to corrosives, including the agitator, is made, or sheathed with, HAYNES Tantalum. For full details on this new material, write for descriptive booklet.

HAYNES ALLOYS

HAYNES STELLITE COMPANY

Division of Union Carbide Corporation

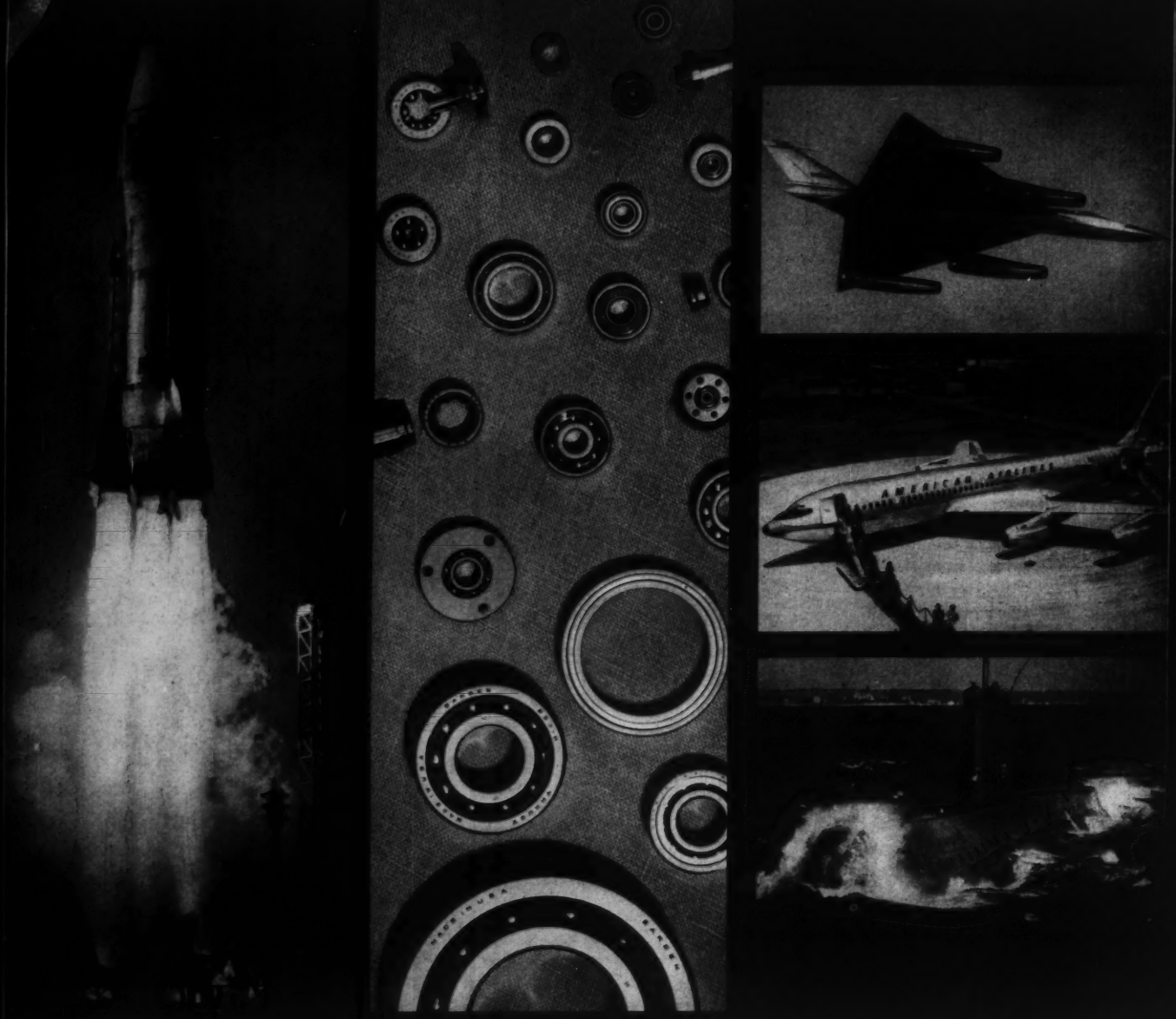
Kokomo, Indiana

UNION CARBIDE

Address inquiries to Haynes Stellite Company, 420 Lexington Ave., New York 17, N. Y.

"Haynes," "Haynes Stellite," and "Union Carbide" are registered trade-marks of Union Carbide Corporation

Circle 473 on Page 19



Wherever reliability is vital...
you'll find **BARDEN PRECISION** ball bearings

Barden Precision ball bearings are basic components in the instruments and mechanisms that meet today's toughest requirements for systems reliability. You'll find them in navigation and flight instruments...in guidance and control systems...in computers, turbo-driven equipment and ground support instrumentation...wherever reliability is vital.

When you need top bearing performance, Barden provides it with functionally tested bearings of uniform quality—standard or special—for prototypes or extended production runs. Because Barden is exclusively a producer of highest precision ball bearings, you get the full benefit of its specialized design, manufacturing and application experience.

The complete Barden line includes bearing sizes from .0469" bore to over 3" O.D., all produced to Barden Precision standards of dimensional accuracy, uniformity and reliability. Write for catalog and bearing selection guide.

for reliability...specify **BARDEN PRECISION BALL BEARINGS**

THE BARDEN CORPORATION, 73 East Franklin St., Danbury, Connecticut
Western office: 3850 Wilshire Boulevard, Los Angeles 5, California.

Circle 474 on Page 19

CONTROL FLUID FLOW

with Micrometer Accuracy

HANNA Flo-Set VALVES

For AIR, OIL and WATER operation to 250 p. s. i.
SIZES ¼" • ⅜" • ½" • ¾"
TEMPERATURES to 250°F

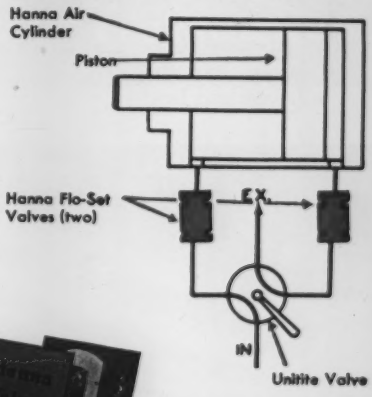
Hanna Flo-Set Valves are used to control cylinder piston speeds and operating speeds of many types of fluid actuated mechanisms. They are able to handle air, oil, water and many gases. When used with cylinders, these valves permit independent adjustments of forward and return piston speeds. The diagram at the right shows a typical circuit. Flo-Set Valves make the operation of air cylinders smoother and make cushioned cylinders more effective by building up essential back pressure.

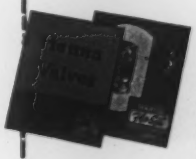
Fluids pass unobstructed in the direction of the arrow on Hanna Flo-Set Valves. In the opposite direction, flow can be controlled from zero to full pipe capacity. One valve can be set to an infinite number of controlled flow positions. Once set, the position can be held by means of a locking collar. Established flow positions can be reset by using the micrometer graduations which accurately measure flow as a percent of full pipe capacity.

One revolution of the aluminum valve body will change the flow rate from zero to full capacity. No tools are necessary! In addition to the standard ¼", ⅜", ½" and ¾" sizes, there is a ¼" Jr. model, without micrometer graduations or locking collar, for light piping and tubing.

Typical Cylinder Circuit Using Hanna Flo-Set Speed Control Valves

Hanna engineers will gladly recommend circuits to help you with your applications.





Consult your classified telephone directory or Thomas' Register for your nearest Hanna representative. Write for Hanna Valve Catalog 254 and Flo-Set Valve Bulletin 253A.

Hanna Engineering Works

HYDRAULIC AND PNEUMATIC EQUIPMENT . . . CYLINDERS . . . VALVES . . . RIVETERS

1751 Elston Avenue • Chicago 22, Illinois

PROTECTED BY Bonderite PARKER RUST PROOF CO. QUALITY CORROSION RESISTANT

Bonderite's best for Aluminum, too!

Better paint adhesion, better corrosion control

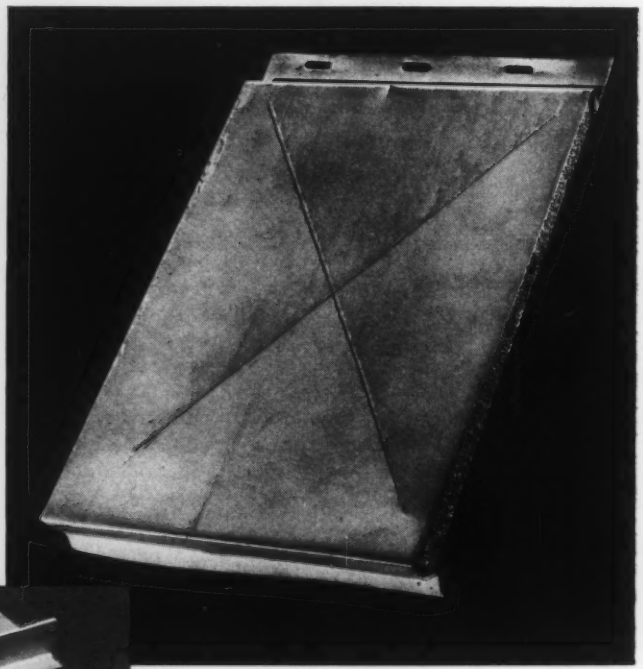
Here's the most famous name in the whole metal treatment field. Bonderite!

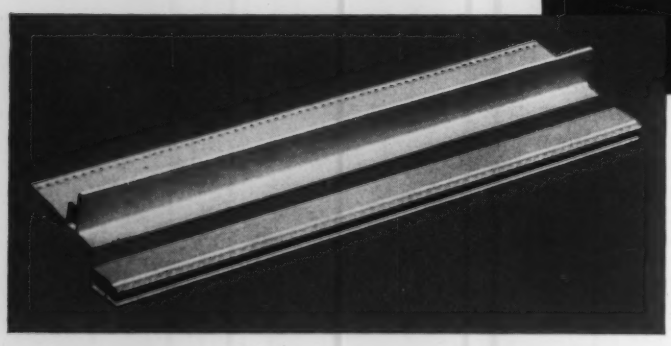
This is the product name that has meant finest finish protection and customer satisfaction to buyers of automobiles, home laundry equipment, refrigerators, metal furniture and other painted metal products for a generation.

This year, over 10 million Bonderite seals will be used on metal products to tell buyers they are getting the plus values of Bonderite protection.

As protection for aluminum, Bonderite's performance is equally spectacular. It controls corrosion, anchors paint.

Sell aluminum siding, awnings, windows, doors and panels that are protected by Bonderite. Sell with complete confidence that the product's good looks will last and last!





(Above): Regular 1-coat paint finish over section of Bonderite-treated aluminum siding. Formed after painting. Tested in salt spray 1500 hours. (Siding by Hastings Aluminum Products, Inc., Hastings, Mich.)

(Left): Aluminum window and screen frame sections Bonderized, painted in the strip, formed after painting. No breaks in finish anywhere! (Frame by The Security Companies, Detroit, Mich.)

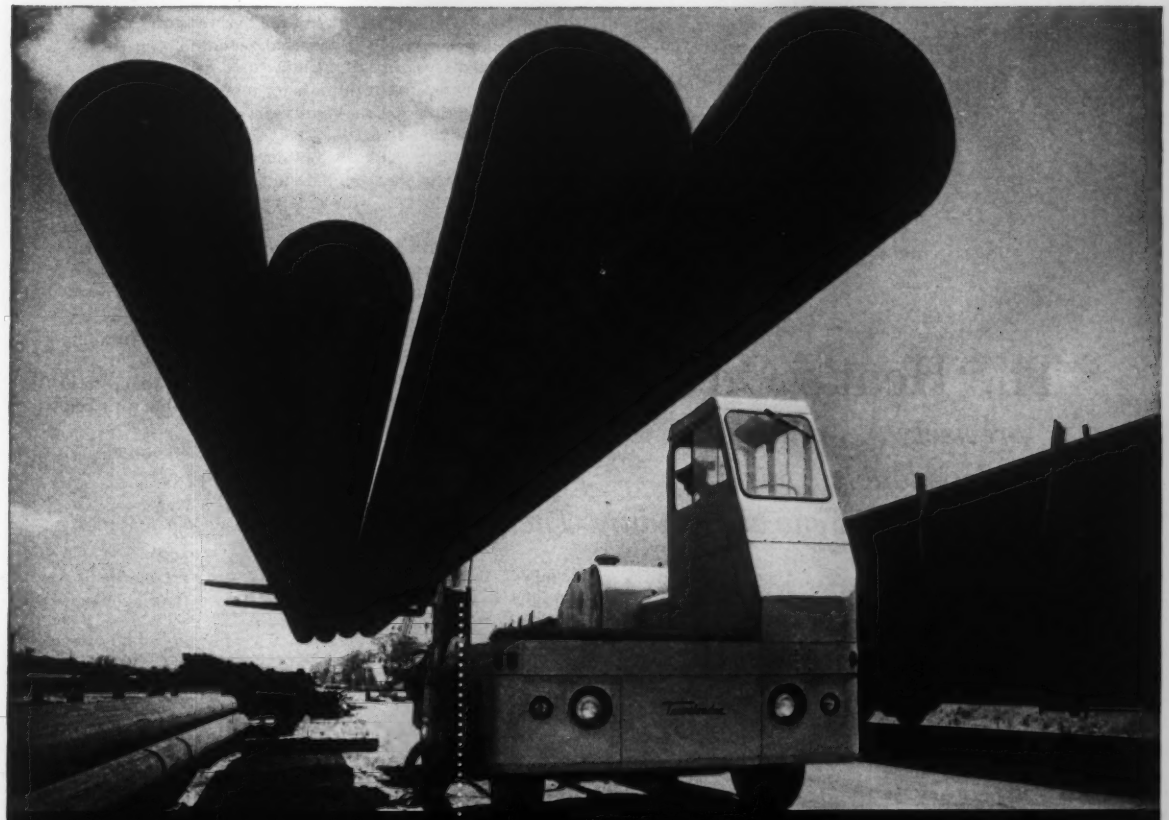
Since 1914—leader in the field

Parker Rust Proof Company

2193 E. MILWAUKEE, DETROIT 11, MICHIGAN

BONDERITE corrosion resistant paint base	BONDERITE and BONDERLUBE aids in cold forming of metals	PARCO COMPOUND rust resistant	PARCO LUBRITE—wear resistant for friction surfaces	TROPICAL—heavy duty maintenance paints since 1883

**Bonderite, Bonderlube, Parco, Parco Lubrite—Reg. U.S. Pat. Off.*



DYNAMIC DIFFERENCE

in hydraulic performance

"HC" SERIES

POSITIVE DISPLACEMENT GEAR-TYPE PUMP

Shaft seal: lip type
Drive: direct, gear or belt
Capacity: 5 sizes, 5 - 17 gpm
Pressures: to 1500 psi
Operating speeds: to 2400 rpm
Porting: side (Std.) end (Opt.)
Valve: Optional; internal relief, adjustable 800 - 1500 psi

BULLETIN HY1 gives complete engineering characteristics — performance and installation data.

Call the man from Webster

. . . he's one of a staff of engineers, specially trained in hydraulic application. He can help you solve special problems when hydraulics become a part of your design!

photos Baker Industrial Trucks, div. of Otis Elevator Co., Cleveland, O.

Webster

POSITIVE DISPLACEMENT GEAR-TYPE PUMPS

Yesterday's pipe dream is today's nimble-fingered reality. This versatile fork lift truck unloads and stacks — carries a full platform load. The heart of its powerful hydraulic system is a Webster Gear-Type Pump. Just another example of Webster's practical and economical adaptation to hundreds of hydraulic applications . . in lift systems, pressure lubricating, oil circulating . . . in industrial, agricultural and construction equipment.

Webster Gear-Type Pumps present many advantages in design "fit" and application — with unusual standardization and interchangeability of components. Keep Webster in mind when you plan hydraulics — for the dynamic difference that pays!

OIL HYDRAULICS DIVISION

WEBSTER ELECTRIC

RACINE · WIS

our 50th year

franklin adv. H-113

Circle 477 on Page 19

The Heat's On

precisely . . . under the dependable control of Fenwal Standard Thermoswitch® Units

Key step in the manufacture of milk cartons on Pure-Pak carton-forming machines is the heat-sealing of the bottom flaps. For eight years this manufacturer has used Fenwal Series 17000 THERMOSWITCH units for temperature control of this vital operation. Result: eight years of precise troublefree control. *That's time-tested performance!*

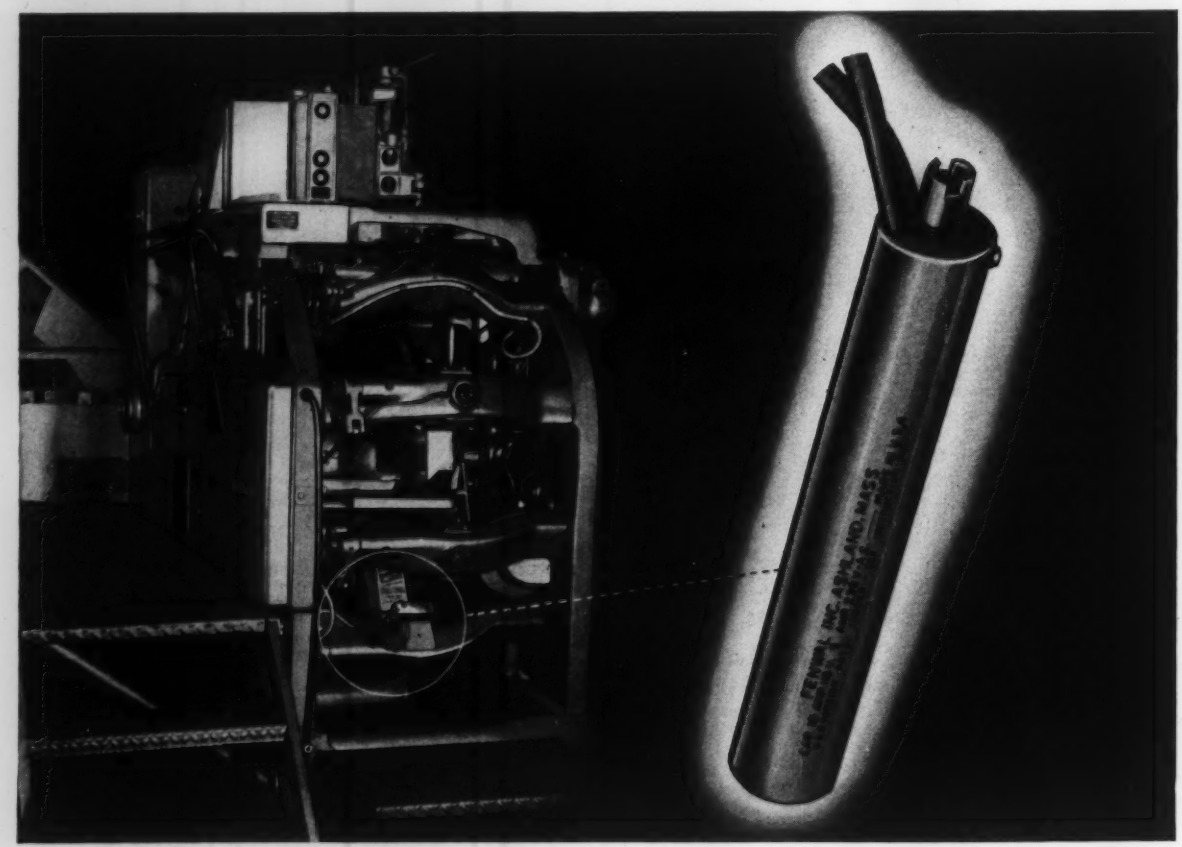
It's typical of the hundreds of successful installations of immersion and surface-mounted THERMOSWITCH units . . . in tanks, vats, air ducts . . . for widely varying space and position requirements . . . under the severest conditions of shock, vibration, and corrosion. *They're standard units with truly special capabilities!*

Yet for all their ruggedness, THERMOSWITCH units are sensitive to temperature changes of only a fraction of a degree. Heat sensitive outer shell responds instantly and accurately. *No thermal lag . . . no control error!*

Use these versatile units for control applications from −100 to +1100°F. They're completely adjustable with current ratings up to 10A-115VAC.

For complete details, write Fenwal Incorporated, 199 Pleasant Street, Ashland, Mass.

Compact, totally-enclosed Fenwal THERMOSWITCH units provide positive, service-free control of heat-sealing operation on this Pure-Pak carton-forming machine.



ANOTHER EXAMPLE OF HOW **Fenwal** CONTROLS TEMPERATURE . . . PRECISELY

interchangeable with all standard JIC cylinders

With the introduction of the ALL NEW T-J Squair Head, Tomkins-Johnson now offers industry the most complete design range of air and hydraulic cylinders. Presently available in bore diameters from 1½ to 8 inches, the T-J Squair Head is an interchangeable cylinder which produces maximum force and efficiency, with minimum pressures... and is also adaptable to the use of low pressure oil as the working medium. Write to The Tomkins-Johnson Co., Jackson, Michigan, for Bulletin #SQ 10-58 and complete details.

CHECK THESE 10 POINTS OF T-J SUPERIORITY

1 One Piece Piston

2 Hard Chrome Cylinder Bore and Piston Rods

3 High Tensile Steel Tie-Rods

4 Cushion Adjusting Screw, Externally Adjustable

5 New Super-Cushion for air, or Self-Aligning Master Seal for Oil (T-J Patents)

6 Solid Steel Heads and Mounting Plates Standard all Models

7 Port Design Allows Minimum Pressure Drop on Inlet or Outlet

8 Chevron Type, Self-Adjusting Rod Packing

9 Piloted Packing Gland—Absolute Alignment

10 Piston Rod, Extra Strong—Polished and Chrome Plated for Efficiency and Protection

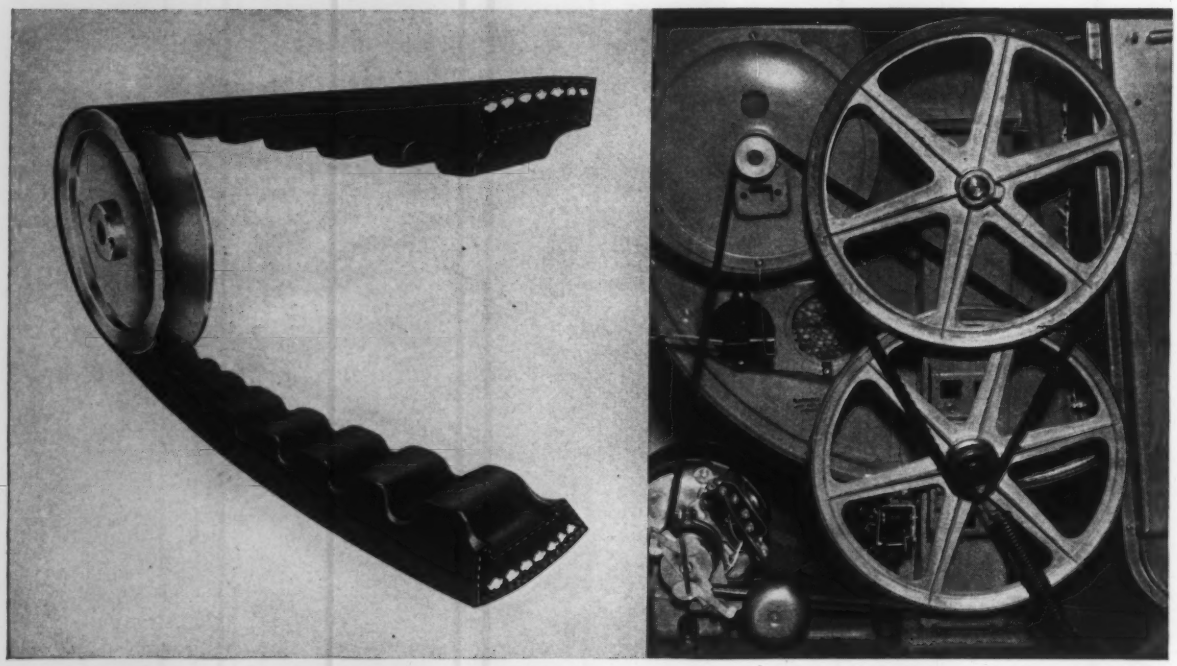
T-J TOMKINS-JOHNSON

Circle 479 on Page 19

CUT COSTS, IMPROVE DESIGN AND PERFORMANCE WITH R/M PRODUCTS

RUBBER

Write today for free booklet shown: full details on a wide variety of industrial rubber products.
Manhattan Rubber Division, Raybestos-Manhattan, Inc.
Passaic, N.J.



NOW...A NEW DESIGN IN LUGGED V-BELTS

Outlasts Other Belts as Much as 8 to 1

R/M introduces new CX V-Belt . . . *the only fully molded, fully jacketed lugged belt*. Extensive tests have proved it outperforms, outlasts other makes of belts as much as 8 to 1. Fully molded and full fabric cover prevents flex-cracking, improves fatigue resistance, has less distortion because of lateral stability, maintains more effective length. It's the ideal lugged belt for small pulleys where flexibility and ruggedness, with extremely quiet running, are important factors.

Other R/M V-Belt Designs

R/M engineering makes other V-belts to meet a wide variety of light and heavy duty requirements. For example, R/M FHP V-Belts eliminate troublesome vibration problems on motorized appliances, air conditioners, power tools. An exclusive molding process positions and controls every belt part to assure balanced belt power delivery without whipping or slapping.

On heavy duty multiple belt drives. Condor V-Belts with flat sidewalls assure *more* grip, *less* slip . . . longer belt life.

Now transmit 40% more power than conventional V-belts at no increase in cost. Condor V-Belts give you premium V-belt construction at standard V-belt prices.

For space saving, no matching problems, and other advantages use the patented R/M Poly-V Drive, a revolutionary new concept in heavy duty power transmission.

Let R/M rubber specialists work with you on V-belts, transmission or conveyor belting, rubber hose, molded or extruded parts.

R M

Brake Blocks, Linings and Clutch Facings

Mechanical Packings and Gaskets

Abrasive and Diamond Wheels

Industrial Drive Belts

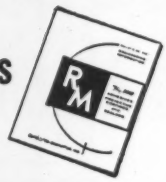
Industrial and Automotive Hose

Conveyor Belts

Circle 480 on Page 19

SPECIALISTS IN ASBESTOS, RUBBER, SINTERED METAL, ENGINEERED PLASTICS

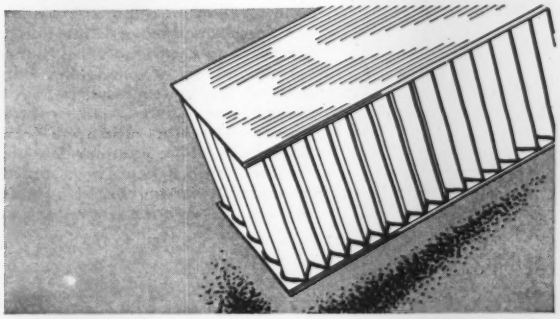
ADHESIVES



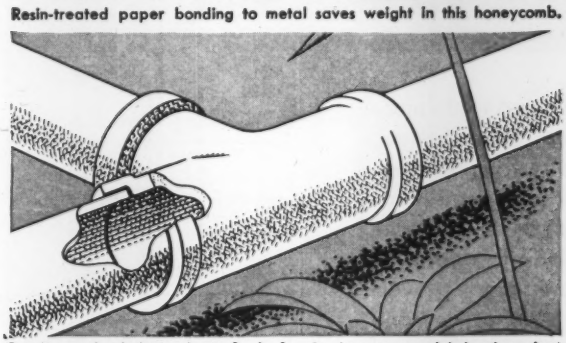
Send today for free copy of R/M Bulletin No. 700 on Ray-BOND adhesives, protective coatings and sealers.
Adhesives Department
Raybestos-Manhattan, Inc.
Bridgeport, Conn.

PACKINGS

Complete information on packings shown and many others is given in free booklet. Send for it today.
Packing Division,
Raybestos-Manhattan, Inc.
Passaic, N.J.



Resin-treated paper bonding to metal saves weight in this honeycomb.



Bonding polyethylene plastic firmly for use in sewer and irrigation pipe.

Cutting Costs—and Corners in Product Assembly

With costs up and profits down, today is a better time than ever to check the advantages of adhesive bonding.

R/M Ray-BOND® Adhesives are now speeding assemblies and saving money in a broad range of different applications. Ray-BOND Adhesives have excellent bonding qualities and heat stability. They resist temperatures from −80°F to +700°F—give superior performance in meeting widely varied requirements, under many different destructive liquids, gases, atmospheres and physical conditions. And they have an impressive record for simplifying assemblies that were formerly difficult or impossible.

With over 20 years' pioneering in the production of bonded assemblies and the manufacture of adhesives and coatings, Raybestos-Manhattan is in a special position to demonstrate what adhesive bonding could do for you. Write for more specific information on your business letterhead now.

R/M Fabric Piston Cups R/M Vee-Flex Rings

Controlled molding assures dimensional uniformity in R/M Piston Cups and "V-Rings"

R/M piston cups for hydraulic and pneumatic cylinders are designed and precision molded from a wide variety of modern synthetics to give maximum service with a minimum of friction. The clearly defined contours and cleanly trimmed edges assure strict adherence to industry's standard sizes. They are produced in varying degrees of hardness for pressures up to 1500 psi. Our engineers will gladly recommend the proper R/M piston cup for your specific operating conditions.

R/M Vee-Flex® packing rings, for use on steam or air rods, hot oil pumps, hydraulic cylinders, rams, presses, lifts, and a wide variety of other equipment, and precision molded in five types in varying degrees of hardness. They are self-sealing and self-adjusting for pressures up to 1500 psi.

RAYBESTOS-MANHATTAN, INC.

FACTORIES: Passaic, N.J. • Bridgeport, Conn. • Manheim, Pa. • Paramount, Calif. • No. Charleston, S.C.
Crawfordsville, Ind. • Neenah, Wis. • Peterborough, Ontario, Canada

Rubber Lined and Covered Equipment

Sintered Metal Friction Elements

Asbestos Textiles

Industrial Adhesives

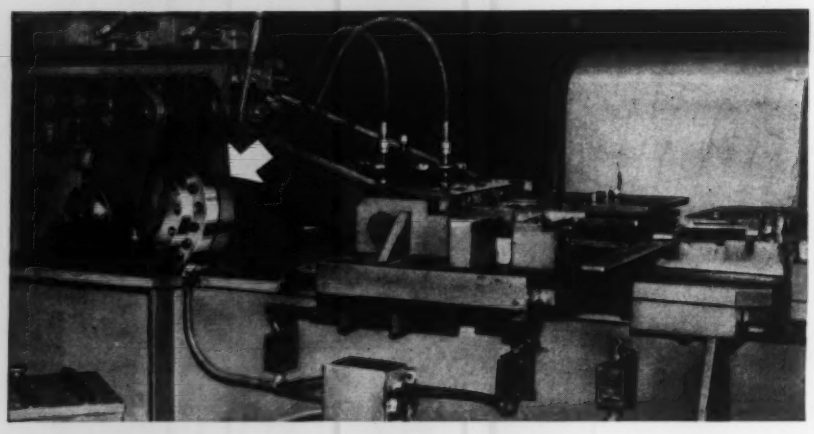
Teflon Tape, Packings, Sheets, Rods, Tubes

Engineered Molded Rubber and Plastics

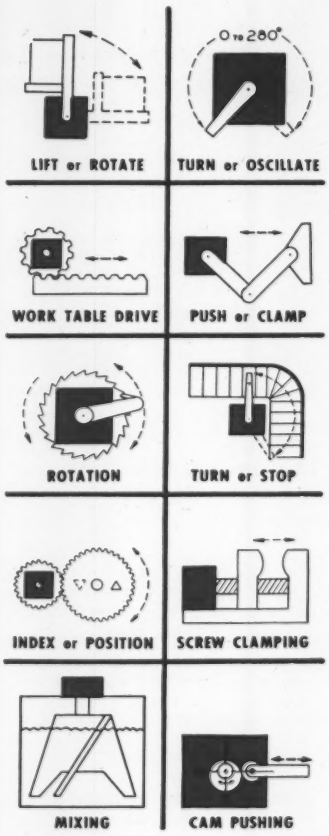
RŌTAC®

EXERTS 60-TON FORCE

. . . *In 1/6th the Space of a Straight-line Actuator!*

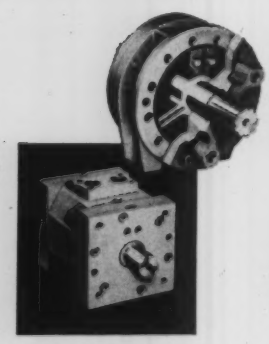


Left: **Every 1½ minutes, a Model HN Rōtac Torque Actuator on this wire-forming machine exerts a 60-ton force on the work through a simple toggle arrangement. Higher torque and higher speed—in a fraction of the space required by a straight-line power unit, control valves and motor—add up to Rōtac efficiency! (Photo courtesy Stubnitz Greene Corp.)** ***Below:*** **These typical Rōtac applications might suggest the answer to your design problem:**



Rōtac Reciprocating Rotary Torque Actuators are designed to do more jobs that cannot be done easily or economically with other devices. **Torque** is instantaneous and uniform through the required arc. **Ratings** range from 100 to 40,000 inch-pounds for standard single-vane models, from 240 to more than 200,000 inch-pounds in double-vane models. **Power source** can be air, oil or other fluids, with operating pressures to 1,000 psi in standard Rōtac units. **Mounting** can be vertical, horizontal or at any angle, and RN models can be safely manifold mounted. **Rotation or oscillation** (to 280° in single-vane models) can be stopped, started, slowed down or speeded up. **Application** is unlimited; among hundreds of uses are mobile installations, machine tool and various light and heavy industrial applications. **Construction** conforms to J.I.C. standards, and to Ex-Cell-O's own high requirements for precision, long life and low maintenance. **Special designs** available for unusual applications, military and aircraft use. **Delivery** of a wide range of standard catalog models is fast. See your local Rōtac Representative or write direct.

59-R-2



FREE DESIGN DATA BOOK—20 PAGES

Contains everything you'll want to know about RŌTAC—How it works • Control • Typical applications and special uses • Installation details • Dimensions • Torque ratings.

EX-CELL-O CORPORATION

Greenville Plant, 945 E. Sater St., Greenville, Ohio

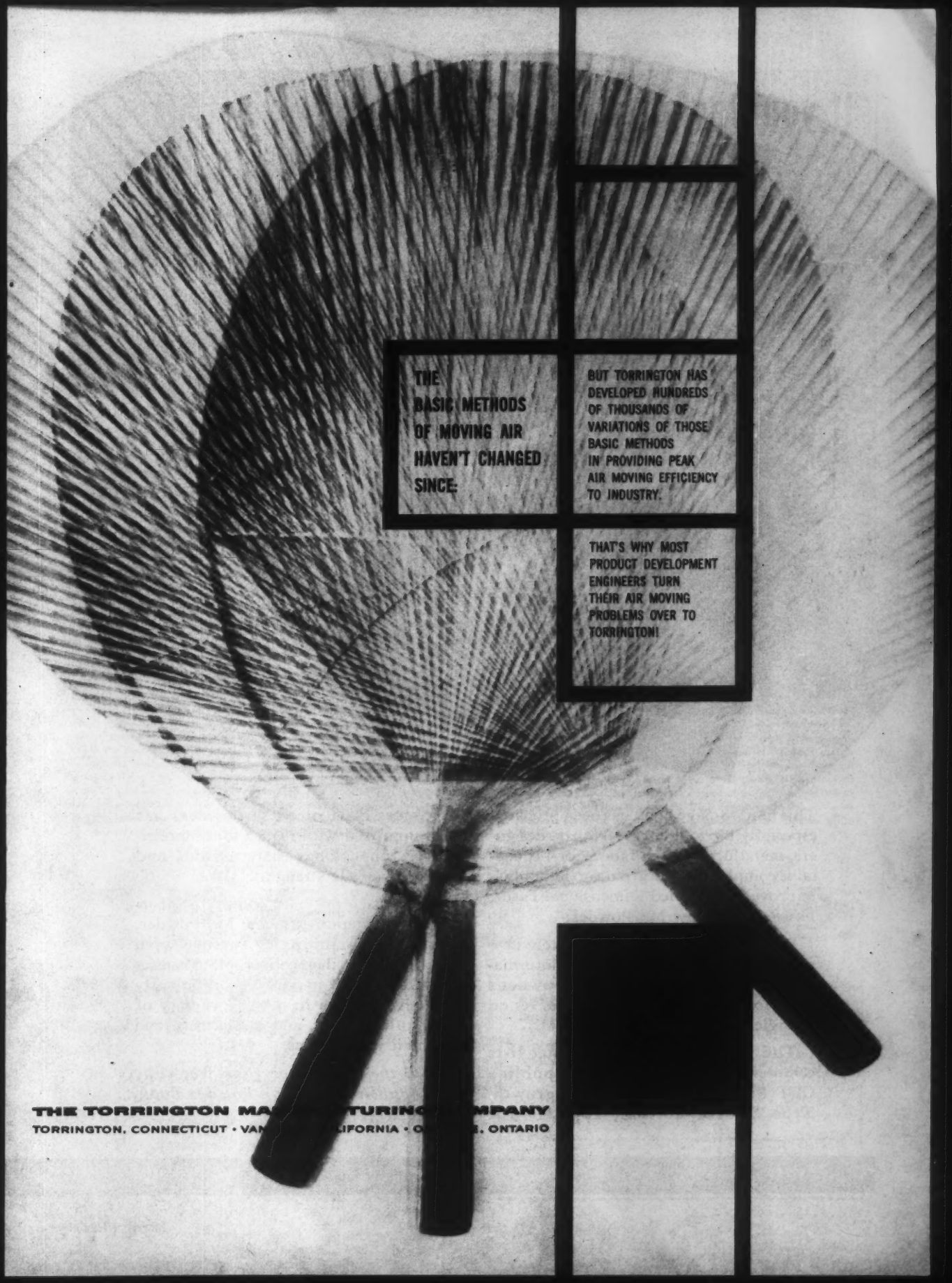
XLO

EX-CELL-O FOR PRECISION

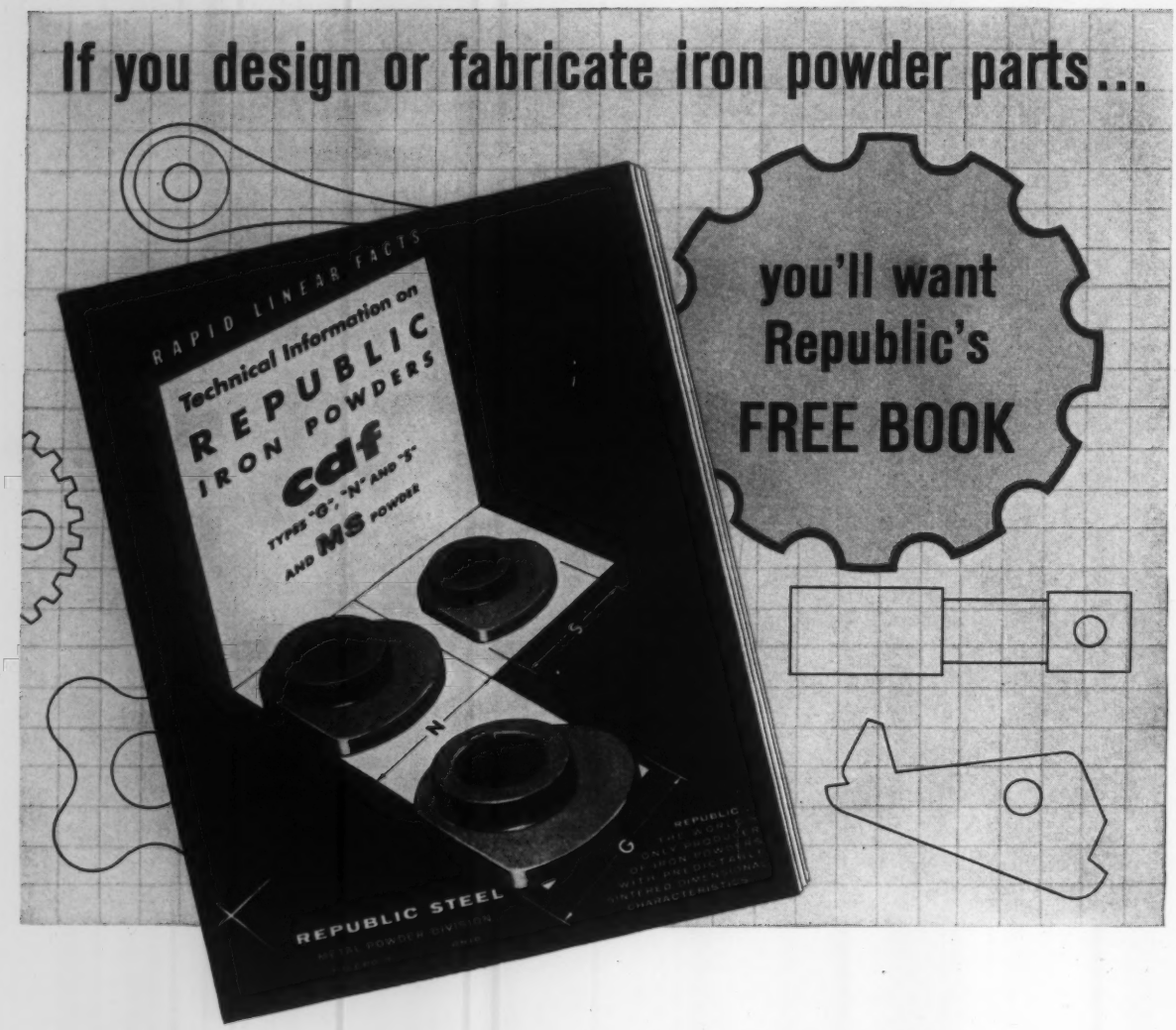
EX-CELL-O PRECISION PRODUCTS INCLUDE: MACHINE TOOLS • GRINDING AND BORING SPINDLES • CUTTING TOOLS • RAILROAD PINS AND BUSHINGS • DRILL JIG BUSHINGS • TORQUE ACTUATORS • THREAD AND GROOVE GAGES • GRANITE SURFACE PLATES • AIRCRAFT AND MISCELLANEOUS PRODUCTION PARTS • DAIRY EQUIPMENT

Circle 483 on Page 19

Circle 484 on Page 19→


THE BASIC METHODS OF MOVING AIR HAVEN'T CHANGED SINCE.
BUT TORRINGTON HAS DEVELOPED HUNDREDS OF THOUSANDS OF VARIATIONS OF THOSE BASIC METHODS IN PROVIDING PEAK AIR MOVING EFFICIENCY TO INDUSTRY.
THAT'S WHY MOST PRODUCT DEVELOPMENT ENGINEERS TURN THEIR AIR MOVING PROBLEMS OVER TO TORRINGTON!
THE TORRINGTON MA TURING MPANY
TORRINGTON, CONNECTICUT • VA IFORNIA • O I, ONTARIO

If you design or fabricate iron powder parts...



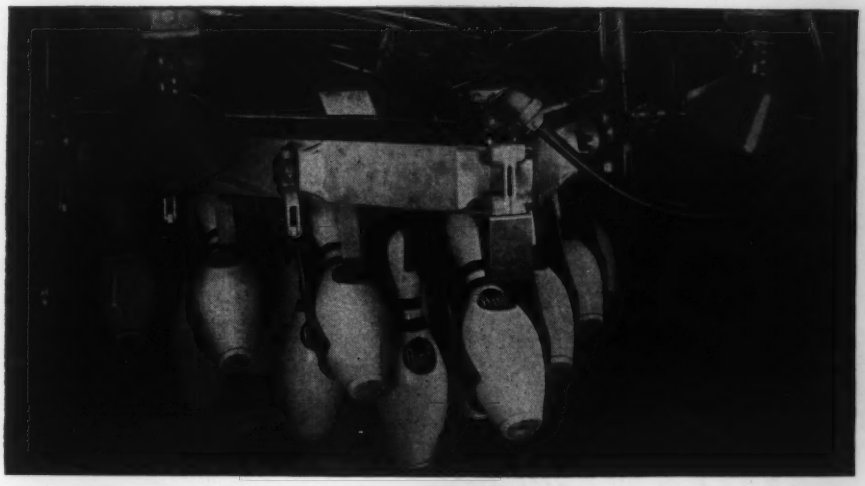
This new 48-page book has been prepared especially for tool engineers, part designers, metallurgists, and fabricators. It contains complete technical data on Republic's improved Controlled Dimensional Factor Powders and new MS Powder.

Data are presented by an entirely new method. Most of the necessary information regarding a particular powder's behavior can be read from the curves on a single set of ordinates.

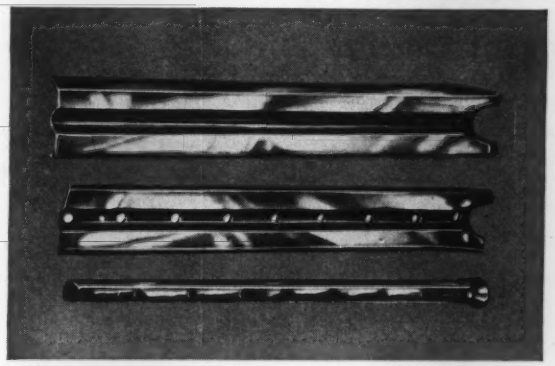
The first section of the book lists complete specifications for Republic's CDF Powders, Type "G" for growth, Type "N" for normal, Type "S" for shrinkage. Each of these powders has been improved with regard to compressibility, dimensional characteristics, and increased tensile strengths.

Section two provides complete information on Republic's new MS Powder, developed principally for use with graphite rather than copper. MS possesses features which make it economically attractive for use in a wide variety of mechanical parts, and in electrical and magnetic applications.

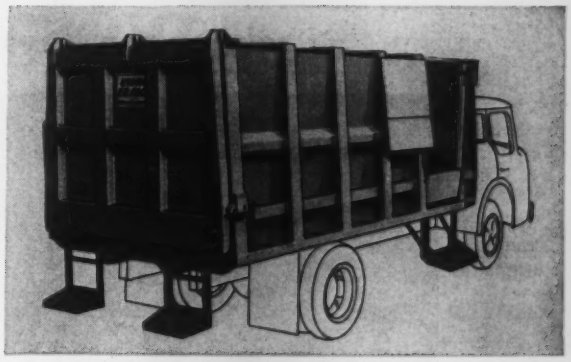
Mail the coupon for your free copy of Republic's new Iron Powder Book, ADV. 1014.



AMF CUTS COSTS, builds a better pinspotter with Republic ELECTRUNITE® Mechanical Tubing. On the initial order, ELECTRUNITE saved American Machine & Foundry Company, Brooklyn, New York, $34,000 in manufacturing their famous AMF Automatic Pinspotter. AMF was able to eliminate boring and grinding operations because ELECTRUNITE met O.D. tolerance requirements. This feature resulted in a savings of $15,000 in fabricating operations. Another $19,000 was saved on the cost of ELECTRUNITE as compared with tubing previously used. In uniformity, quality, original costs, Republic ELECTRUNITE Mechanical Tubing can save you time and money, too. Call Republic, or mail coupon for facts.



GREATER STRENGTH, CORROSION-RESISTANCE, and cost were prime factors in switching to stainless steel from brass in this automotive engine water distribution tube. Stainless was easily fabricated on existing tools. It took the constant flow of hot water and anti-freeze chemicals in stride. The greater strength of stainless virtually eliminated loss from bent or damaged tubes. Photo sequence shows fabricating operations: (1) Blank of .010" stainless strip after initial drawing and embossing, (2) Same blank after piercing of water outlet holes and trimming of flanges, (3) Completed tube after roll-forming and lock seaming. Mail coupon for more information on Republic ENDURO® Stainless Steel.



HIGH STRENGTH STEEL SOLVES WEIGHT PROBLEM in Hydro E-Z Pack enclosed truck bodies, manufactured by Hercules Galion Products, Inc., Galion, Ohio, for haulers of refuse and garbage. Tough, strong, lightweight Republic "50" High Strength Steel allows an E-Z Pack unit to be carried on a chassis as small as a two-ton truck. Reduced weight permits increased payload—fewer trips to the dump. High Strength Steel withstands the heavy compressive force of packer blades, allows tight compaction of loaded materials. High resistance to the corrosive and abrasive action of refuse assures long, dependable service. Write for full facts on Republic High Strength Steel.

REPUBLIC STEEL

World's Widest Range of Standard Steels and Steel Products

REPUBLIC STEEL CORPORATION
Dept. MD-6865-B
1441 REPUBLIC BUILDING • CLEVELAND 1, OHIO

☐ Send Iron Powder Book, ADV. 1014

Send more information on:

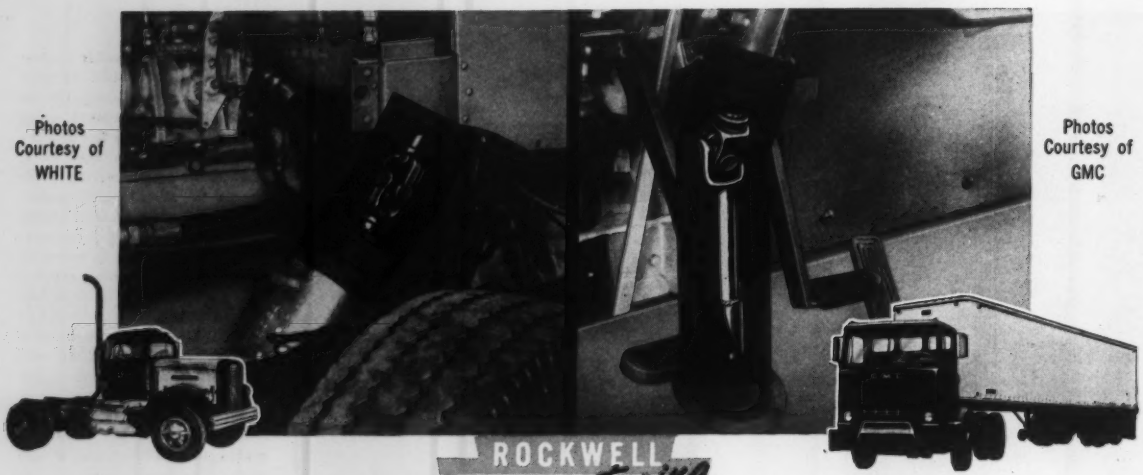
☐ Mechanical Tubing ☐ Stainless Steel
☐ High Strength Steel

Name _____ Title _____

Company _____

Address _____

City _____ Zone ____ State _____



Photos Courtesy of WHITE

Photos Courtesy of GMC

ROCKWELL steering STANDARD

To "take power around corners" rely on the Keystone of Quality...

Photos Courtesy of KENWORTH

Photos Courtesy of REO

...select BLOOD BROTHERS Jointed Steering Shafts

On power steering assemblies for famous-make trucks, Blood Brothers Universal Joints "take power around corners" smoothly and dependably. They're widely used on manual steering assemblies too . . . for road-building and construction machines, farm tractors and self-propelled implements.

When you need universal joints to "take power around corners" — or provide for drive shaft flexibility — be sure to consult Rockwell-Standard. Our engineers will gladly assist you . . . and their experience may save money on your project.

K-1C

L6S, L6N

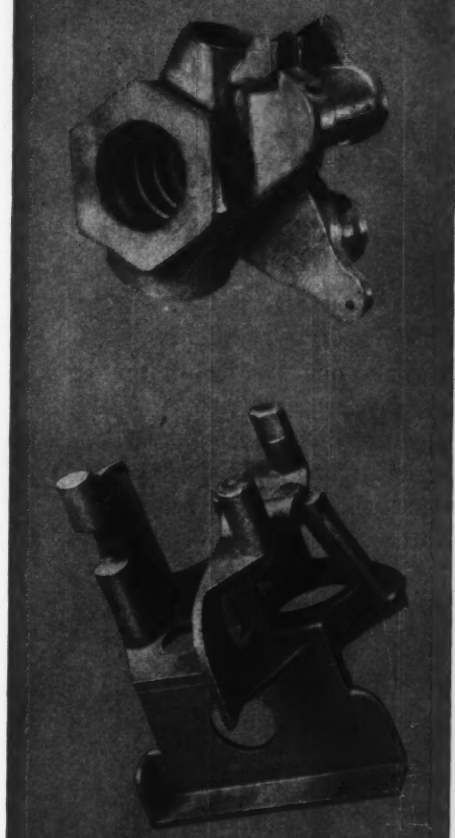
ROCKWELL-STANDARD CORPORATION

Blood Brothers Universal Joints

ALLEGAN, MICHIGAN

© 1959, Rockwell-Standard Corp.

Is your new design complex?



...ask Arwood about investment casting

When you can't simplify the part any more without sacrificing function...

When the production people tell you it will be too costly to machine...

When you think you could cut production costs by making several parts as a single piece...

When function calls for a tricky shape but the intended service makes you specify, a hard, strong, tough-to-work alloy...

When any or all of these design problems are keeping you awake nights... then is the time to consider making the part an Arwood precision investment casting.

Here's why...

Investment casting by Arwood lets you stop worrying about *how to make* the part. You can design for function and end use... Arwood will give you the shape you need, in the quantities you need, from a few hundred to many thousands. Arwood casts all the ferrous and non-ferrous metals and alloys, from aluminum and magnesium right through to stainless steel and cobalt- and nickel-base superalloys.

Write today for your free copy of the new 44-page Arwood "Practical Guide to Investment Casting". It provides all the information you need to evaluate the technique and use it to help solve your design problems.

MACHINE THE SIMPLE... CAST THE COMPLEX

arwood

ARWOOD PRECISION CASTING CORP., 315 W.44th St., N.Y. 36, N.Y.

Sixty-two engineering consultants from coast to coast.

PLANTS IN BROOKLYN, N.Y.; TILTON, N.H.; GROTON, CONN.; & LOS ANGELES, CALIF.

Baffling is the art of filtration...

That's why good engineers throughout industry make use of Dollinger's 35 year experience in making dry type filters for practically every known application. Quite possibly, the problem you have today was solved years ago by Dollinger research. You owe it to yourself, and your company, to find out what Dollinger knows before spending more time developing your own solution.

We don't claim to have "all the answers" on filtration, only a few engineering "short-cuts" that will certainly save you many experimental hours.

Why not investigate Dollinger's facilities, experience, and personnel. Start by writing for brief composite catalog. It describes both standard and special Dollinger filters and their applications.

Write the Dollinger Corporation, 103 Centre Park, Rochester 3, N. Y.

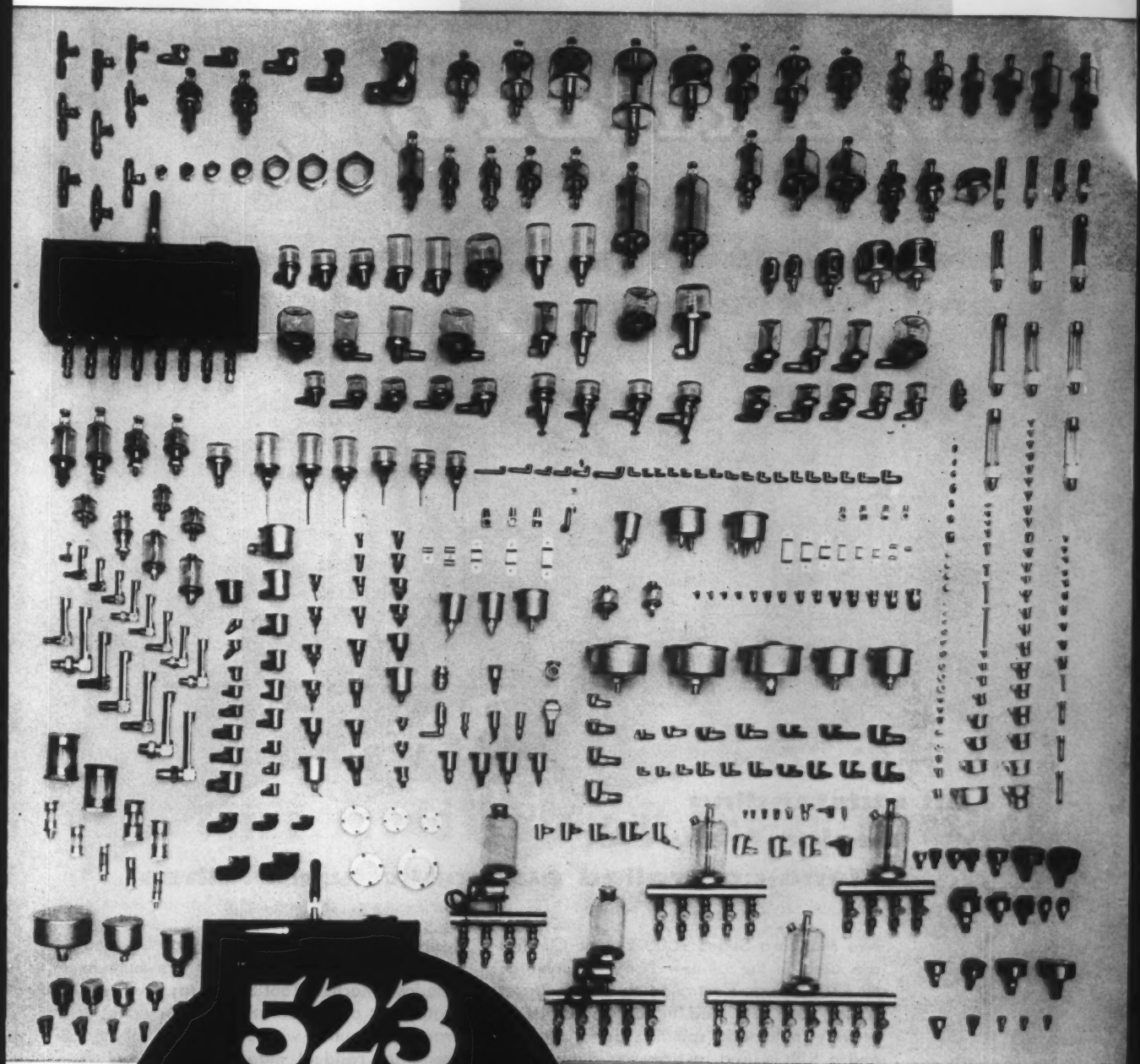
PROTECTOMOTOR

STAYNEW FILTERS

DOLLINGER

SPECIALIZING IN DRY TYPE FILTERS FOR 35 YEARS

LIQUID FILTERS • PIPE LINE FILTERS • INTAKE FILTERS • HYDRAULIC FILTERS • ELECTROSTATIC FILTERS • MIST COLLECTORS • DRY PANEL FILTERS • SPECIAL DESIGN FILTERS • VISCOUS PANEL FILTERS • LOW PRESSURE FILTERS • HIGH PRESSURE FILTERS • AUTOMATIC VENTILATION FILTERS • NATURAL GAS FILTERS • SILENCER FILTERS



523 GITS OILERS AND GAUGES READY TO SHIP

Largest selection available anywhere. You save time and money, because the one you want is always right in stock. Send for complete Catalog.

Specialists in Lubricating Devices and Shaft Seals for Almost Half-A-Century

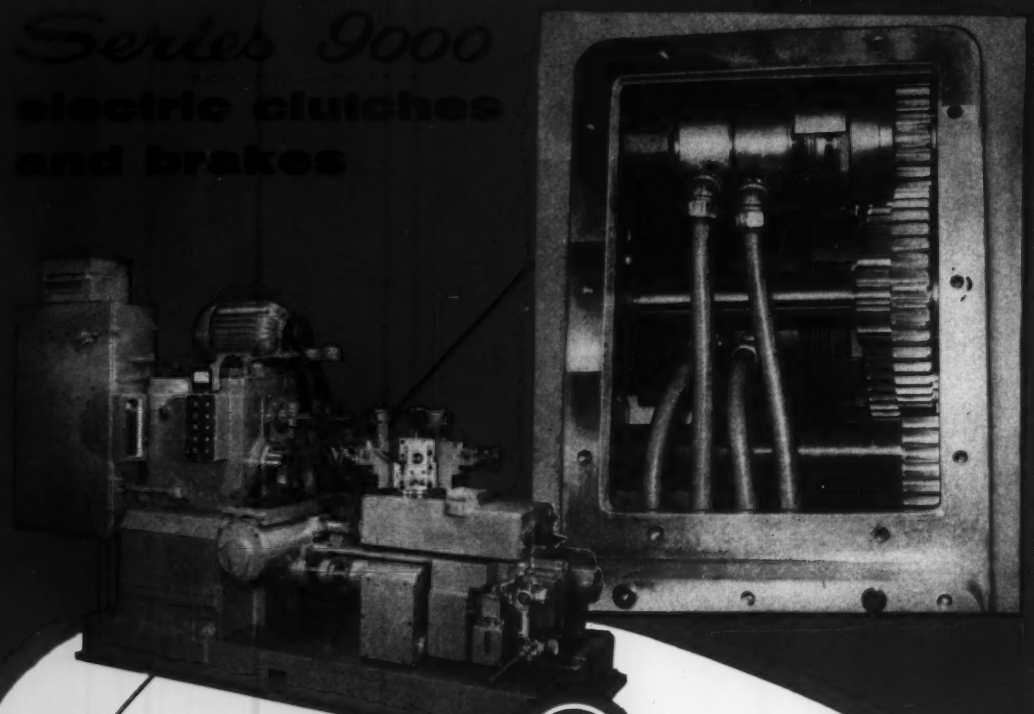
GITS BROS. MFG. CO.

1868C S. Kilbourn Ave., Chicago 23, Ill.

Circle 489 on Page 19

Maxitorq

Series 9000 electric clutches and brakes



an outstanding design feature of tape-controlled automatic turret lathes

Five Maxitorq Series 9000 Electric Clutches are used in the all-new Potter & Johnston No. 3E-15 Tape-Controlled Automatic Turret Lathe. Four are used in the headstock to provide automatic spindle speed changes and a fifth is used as a master clutch in the feed drive. These clutches of advanced design have PROVED their ability to assure consistent, positive and extremely fast action; essential to these machines. They transmit full load, are self-compensating for wear and permit great flexibility in control.

With operation induced entirely by magnetic flux, Maxitorq Series 9000 Electric Clutches are well adapted to a wide range of machine tool drives. They are simple and rugged in design, require no adjustments, can be used *either as a clutch or brake* and are built to American Machine Tool Standards. Disc separators not only separate discs, providing a drag-free neutral without heating, but also break up residual magnetism and permit extremely fast, positive action.

The 9000 Series Clutches have a minimum of moving parts and the electrical operating unit remains stationary, hence, there are no brushes, slip rings or complex wiring. Maxitorq Clutches operate on 110 V. A. C. rectified to 90 V. D. C. Other voltages on special order.

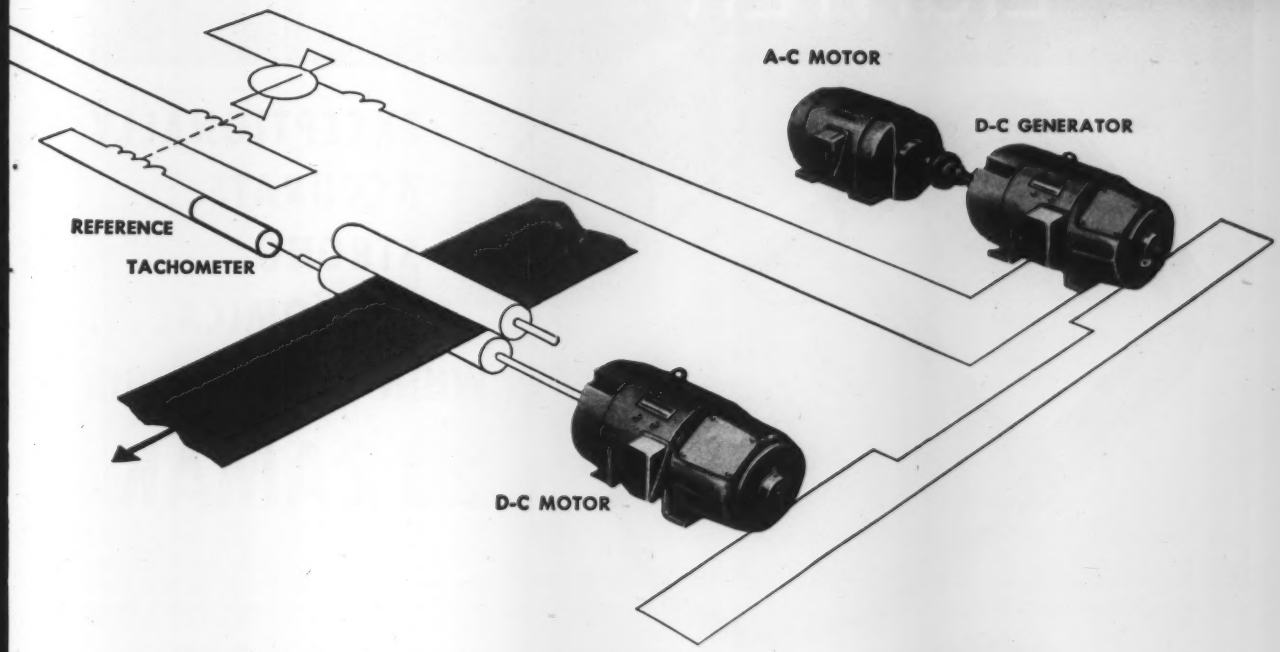
If you have a clutch or brake application where you are looking for new and improved performance, bring your problem to us.

Phone, wire or write Dept. MD for Series 9000 Bulletin.

The Carlyle Johnson Machine Company, Manchester, Conn.

3CJ59

D-C DRIVES FOR PRECISE CONTROL



Problem: How to obtain precise control of machine speeds without human direction

Automation's most important requirement—*self-control*—enables machines to process work continuously with minimum human effort. This is why the trend to continuous automatic processing is a trend to direct-current drives. *For d-c can best supply the precise regulation and self-control that enables a machine to correct its own errors without human direction.*

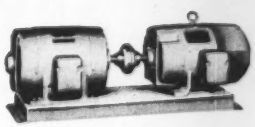
Feedback—the heart of automation—compares machine output with pre-established standards. Deviations are corrected automatically, instantaneously. This is just one example of d-c's modern capabilities.

If you are seeking more automatic, lower cost means of production, it will pay you to investigate direct-current drives. A new booklet, "WHY D-C?", written for modern industry's management team, is available to help you. For your free copy, write *Section 829-4, General Electric Company, Schenectady 5, New York.*

Progress Is Our Most Important Product

GENERAL ELECTRIC

SELECT FROM GENERAL ELECTRIC'S COMPLETE LINE OF D-C DRIVES

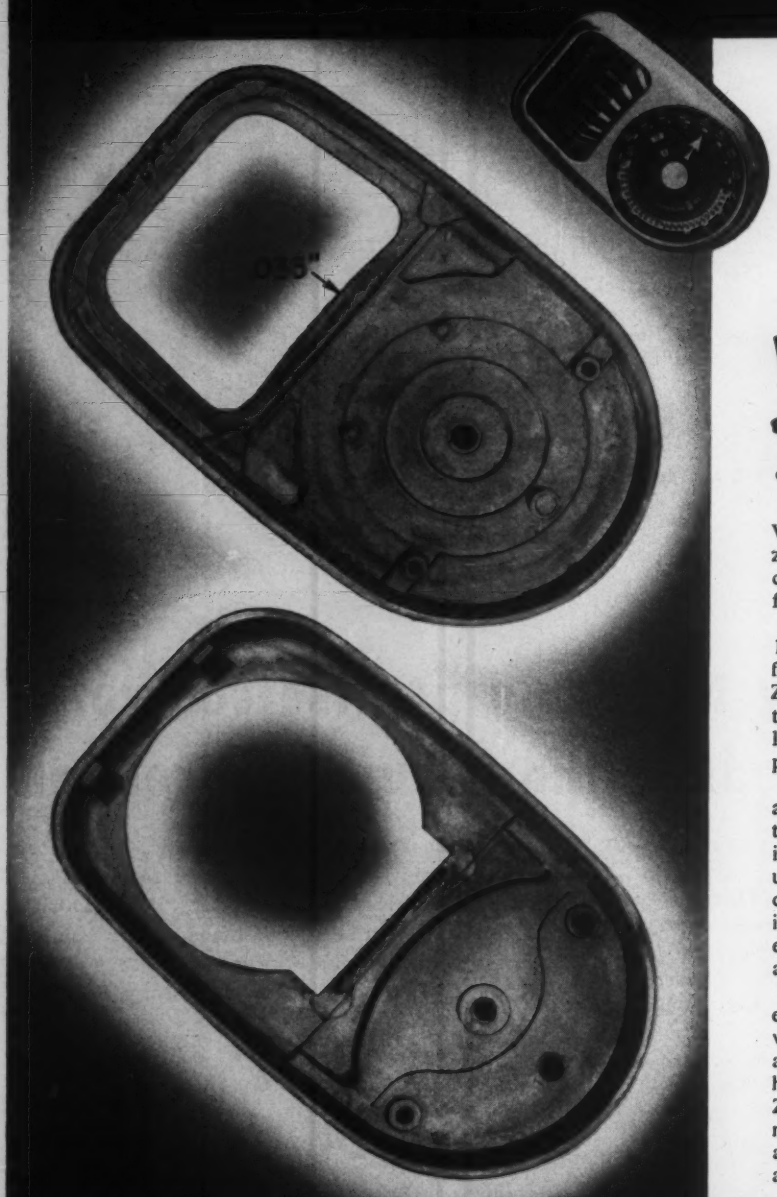


MOTORS AND GENERATORS

POWER UNITS AND CONTROLS

Circle 491 on Page 19

IT'S LIGHTER THAN YOU THINK!



EXCEPTIONALLY ACCURATE... STRONG... ECONOMICAL... WHEN DIE CAST with ZAMAK

WESTON has been using these wafer-thin zinc die castings for the front and back covers of this world-famous exposure meter for 14 years.

Converting from an all-plastic case in 1945, Weston selected zinc die casting alloys for this popular precision instrument because ZAMAK offered the most in all-'round advantages. High strength combined with the lightness of a thin-wall zinc die casting were primary considerations.

Extreme accuracy of dimensions, as-cast, and the convenience of casting contours on the inside of the case for mounting to the instrument were additionally important values. Ease of assembly of the tamper-proof construction and a lasting, satin-chrome finish were extra dividends – all of these and economy, too, when die cast with ZAMAK alloys.

As in many other applications, such extremely thin wall sections – possible only with zinc die castings – minimize weight and are stronger **in proportion to thickness** than heavier sections. Such parts designed for ZAMAK alloy die casting will more than meet competition of either stampings or aluminum castings – provide many more advantages and all at lower cost.

HORSE HEAD® SPECIAL ZINC AND HORSE HEAD ZAMAK ARE PRODUCED BY

THE NEW JERSEY ZINC COMPANY

DEVELOPERS OF THE ONLY STANDARD ZINC DIE CASTING ALLOYS IN USE TODAY

160 Front Street · New York 38, N. Y.

HORSE HEAD PRODUCTS®

MACHINE DESIGN
September 3, 1959

Reward for Responsibility

WHY DO professional groups conduct income and salary surveys? Engineers Joint Council has made three in recent years—in 1953, 1956, and 1958. The National Society of Professional Engineers has had four—in 1952, 1954, 1956, and 1958.

Motivational studies supply an answer. It seems important to an engineer to know that his salary is as much as, or more than, that paid to other engineers at his level of responsibility. Such a feeling appears to be more important to him than the absolute size of his paycheck.

The NSPE surveys, the latest of which was reported recently in our news pages, complement the much larger EJC studies in several interesting ways. EJC, by surveying employers, probably obtained a fairly representative cross section of all engineers in its 190,810-man sample. But NSPE, in approaching only its own 46,000 members, was more selective. Furthermore, the 18,713 return was probably weighted by self-selection, with a predominance of the more successful engineers at each level.

Because of this selectivity, and the detailed analyses by type of work performed, the NSPE survey helps develop a clearer picture of the rewards of high responsibility. For example, the scope of the job in NSPE's highest professional classification (Grade 8) is thus described: "Supervise and direct with final administrative authority a large engineering or research organization comprising major divisions." Median income in this grade is $26,600, compared with $10,000 median for all engineers in the NSPE survey and just under $9000 in the EJC survey. In Grade 8, 90 per cent make over $11,370 and 10 per cent over $48,670.

While the Grade 8 figures represent earnings of the "cream of the crop"—about 5 per cent of those reporting—they afford a new look at the rewards awaiting the talented engineer with ambition.

Colin Carmichael

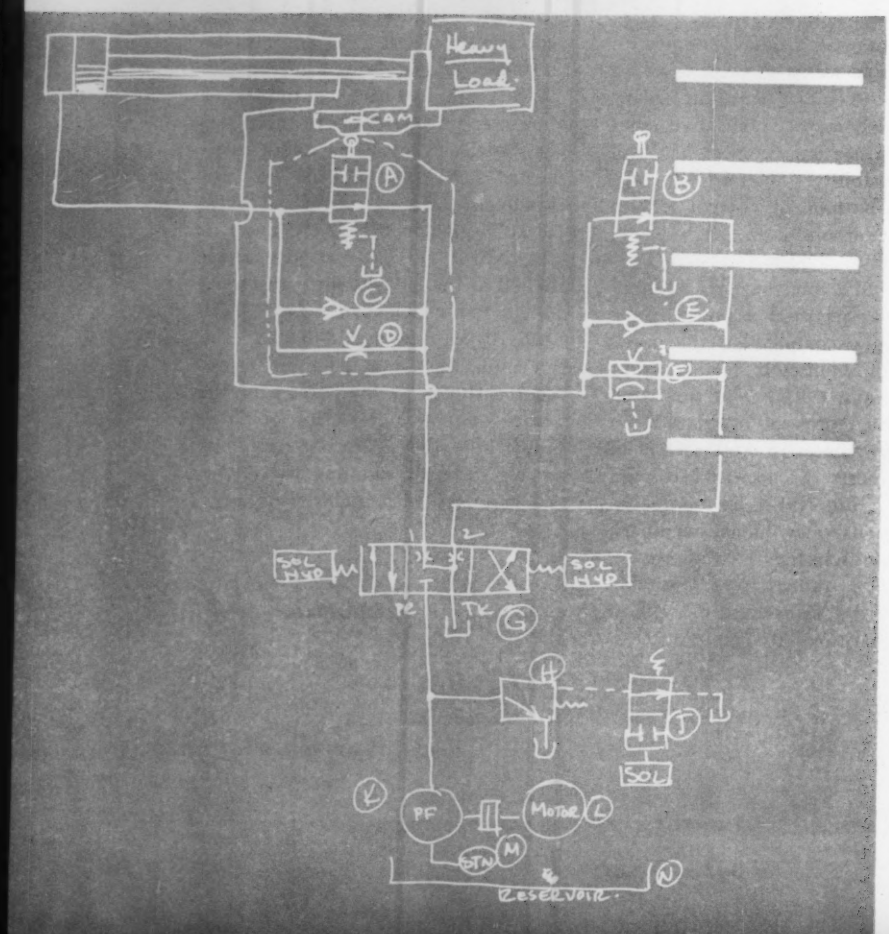
EDITOR

Which System—

Hydraulic or

I. LEONARD KAPLAN
Chief Engineer
Lax Industrial Products
Cleveland, Ohio

Air or oil—or both? Rarely is the choice a free one. Certain key factors dictate the decision:



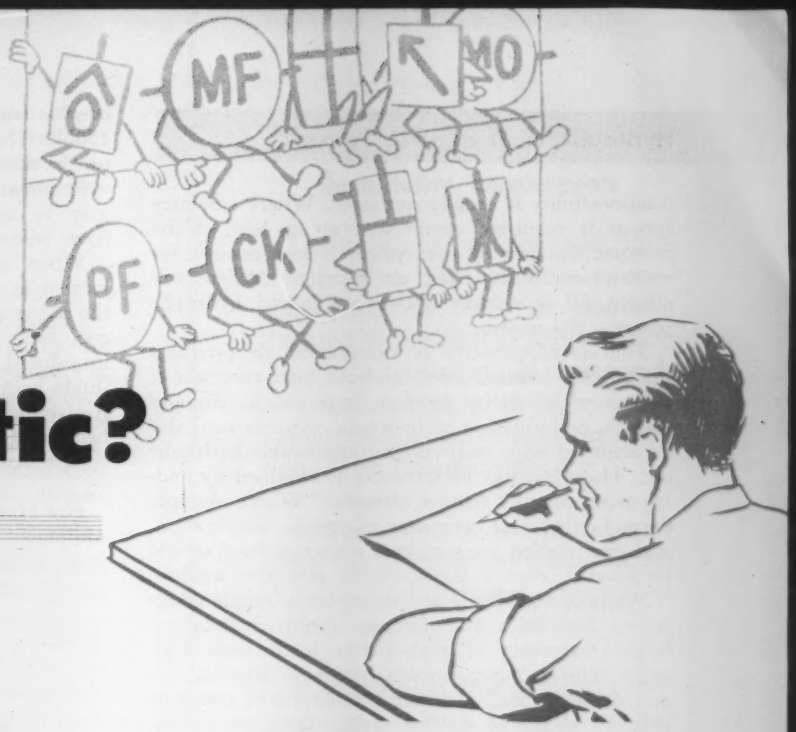
space

medium

environment

economics

components



Pneumatic?

FLUID-POWERED systems are often the best bet for power and control when several high-force functions must be performed in a limited space. But, once other modes of power and control are ruled out, the next problem is to select the right fluid medium for the job.

Any one of the systems—air, oil, or air-oil—can often be used to satisfy the *Quantitative Requirements* desired for a specific function. However, to obtain maximum simplicity and effectiveness, certain physical and economic factors must be included in the comparative analysis.

Space

A cylinder with a relatively low-pressure fluid such as compressed air is larger than a cylinder producing the same force but operated with high-pressure fluid. Where space is limited, fluid pressure for the system must usually be selected on the basis of the largest size actuator that can be used.

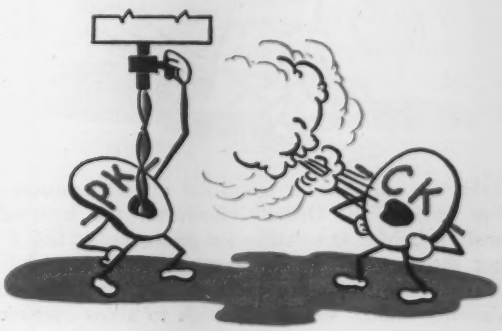
With the valves available today for hydraulic systems, operating pressures as high as 2000 or 3000 psi may be selected without economic penalty. Hence, operating pressures which are high enough to overcome the most frequent space limitation problems can readily be used.

Most shop compressed-air systems today provide maximum operating pressures up to 125 psi. Because of the wide fluctuation in air demands throughout a plant, most compressed-air systems are designed to operate within a pressure range of 80 to 100 psi.

Self-contained and central hydraulic piping systems are commercially and economically available for operating pressures up to 5000 psi. The required operating pressure for a given system is, therefore, the first criterion in determining whether a system should function pneumatically or hydraulically. If a system must operate at pressures which exceed 100 psi, the system should generally be designed as a hydraulic system when high-pressure air is not readily available.

Fluid Medium

The elasticity or compressibility behavior is an extremely important consideration in selecting the fluid medium. Since compressed air is a gas, it is extremely compressible and elastic, and is capable of absorbing large amounts of potential energy. On the other hand, hydraulic oils are relatively incompressible at most operating pressures. Hence, the



compressibility is usually neglected. Where a bouncy system is required, compressed air is best, if the pressure demand of the system is low enough for conventional compressed air supplies. Where relatively stiff or inelastic systems are desired, hydraulic power is the answer.

The elastic property of compressed air produces smooth accelerations, decelerations, and reversals of motion with relative freedom from shock. Equally smooth performance of hydraulic systems can also be achieved with relatively incompressible hydraulic oils. However, this performance is obtained by adding more complex control elements. Where absolute dependability and constancy of speeds, acceleration, and deceleration are required, a viscous fluid should be selected, even if the operating pressures are low.

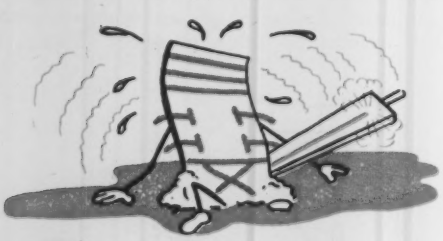
Machine tool feeds are examples of applications where hydraulic systems are almost mandatory. Rapid traversing of high-inertia loads with high cyclic rates demands smooth but rapid accelerations and decelerations. Accurate positioning of actuators requires hydraulic control rather than pneumatic.

Some systems require the elasticity of a pneumatic system even though severe space and weight limitations require the use of compact high-force actuators. For these applications, high-pressure can be designed into the system with high-pressure compressed air, nitrogen, or other gases as the fluid medium.

Environment

Environmental conditions at a machine or system location seriously affect selection of the fluid medium and specific components. The most critical conditions are ambient temperature, operating temperature, fire hazards, safety considerations, and ambient dust or dirt.

Ambient Temperature: Development of high-speed aircraft has accelerated investigation of hydraulic fluids suitable for operation at ambient temperatures as high as 500 F. These fluids are generally operational at other temperatures also. Other hydraulic



fluids are suitable for operation at temperatures as low as −65 F. Usually, however, the hydraulic medium which is suitable for operation at 500 F is not satisfactory for operation at −65 F.

Hydraulic fluids are commercially available with viscosity indices sufficiently high to allow operation over a temperature span of approximately 100 to 150 F. Therefore, hydraulic fluids are suitable for use in most applications, regardless of temperature.

Pneumatic systems, both high and low-pressure, may be operated over a wide temperature range, from below −65 F to over 500 F.

When a system is designed with the actuator located in an area of high ambient-temperature and the power and control elements located in a relatively cool spot, or when artificial cooling elements are introduced, it is generally advisable to use hydraulic fluids because of their relatively high specific heat. A given volume of hydraulic fluid carries away more heat from a hot actuator than a similar volume of compressed gas.

Fire Hazards: For utmost safety to personnel and equipment, commercially available fire-resistant fluids should be used in systems where lines and components are in the immediate vicinity of open flames,

electric sparks, high-temperature furnaces, exposed surfaces of high-temperature molten metals, or other possible ignition sources.

Although even a fire-resistant fluid burns, once the fluid is carried away from the ignition source, burning of the fluid is snuffed out. Hence, burning may occur only in those regions where high temperatures and flames are normally encountered. Use of these fluids prevents flashback to the source of the released fluid, and also prevents the flaming oil from being carried to personnel or equipment.

When explosive atmospheres surround hydraulic or pneumatic systems, special housings should be used to cover actuating solenoids, electric motors, and other control or power elements. For these circuits, piloting for control is generally advisable to cut down the number of electrical components.

Dirt and Dust: When extremely dirty or dusty atmospheres surround pneumatic or hydraulic systems, special considerations and safeguards are required in system design. When the fluid in a hydraulic control system is continuously recirculated, breather filters for reservoirs, strainers for pumping

elements, and fine particle filters must be used to protect valves and other control elements. Since

specialized fluids and components are available to cope with unusual factors, environmental conditions are not as great a factor in deciding whether a system should be pneumatic or hydraulic as they were 5 or 10 years ago.

Economics

Sometimes circumstances of an application do not specifically require one type of system. That is, the system will work equally well either hydraulically or pneumatically. At this point economic factors must be considered, and the hydraulic circuit should be laid out and compared with the equivalent pneumatic circuit. A comparison of the estimated costs of the two circuits usually leads to the ultimate selection of the fluid medium.

Pneumatic Systems: When only the actuating and control components required on the machine are considered, low-pressure pneumatic systems are generally less expensive for relatively low-horsepower applications than equivalent hydraulic systems, if sufficient compressed air is available from centralized compressor facilities. For relatively high-horsepower applications, additional compressor facilities must be added for pneumatic systems. When the cost of additional compressor facilities and accessory equipment is added to the cost of the components, the total cost of a pneumatic system is generally greater than that of a hydraulic system for high-horsepower applications.

Where previous considerations have not required a specific pressure range for a given hydraulic or pneumatic system, the relative economics of each pressure range are useful in selecting a workable pressure range. Since high-pressure compressed air or gas is usually not available in most industrial plants, pneumatic circuits which require high pressure usually are more expensive than equivalent low-pressure circuits.

Hydraulic Systems: Some hydraulic component prices vary approximately with the pressure. Pumps are an example. Single-stage centrifugal pumps, suitable for pressures as high as 20 or 25 psi, are the least expensive. Multistage centrifugal pumps for operating pressures up to 300 psi can handle high-volume flows, and are not as expensive as gear or vane pumps for these flows. Gear-type pumps are in the next price category. In some cases gear pumps are suitable for intermittent pressures up to 2000 psi. Vane pumps are suitable for continuous duty at pressures up to and including 2000 psi. The highest price pumps are the piston type with operating pressure ranges up to 3000, 5000, and 10,000 psi.

Quantitative Requirements

Designing for an intended function involves five quantitative concepts—specific facts or numbers dictated by the desired performance. They must be specified, measured, or calculated to provide basis for system design and component selection. The five concepts are:

1. **Force or torque output** to overcome the external work load or resistance and internal friction or other demands.

2. **Functional time** required to advance and retract, to load and unload, to control the function, etc. Shifting time for directional valves is usually considered instantaneous. However, for circuits with very fast cycling movement, the exact time required to shift each valve component must be considered.

3. **Mass of the load** determining the force required to accelerate the moving system to the required speed.

4. **Distance** required from the stroke of a cylinder or the revolutions of a rotary actuator. Also, physical measurements of the mechanical system determine the clearance limitations or the actual structural characteristics of the actuators.

5. **Sequence** in which the various functions must be performed. A complete system design must include the control and feedback elements. Effective application of these elements depends upon the concepts of force, time, mass, and distance combined with the functional sequence of the overall system.

To keep installation costs down, circuits which require several different flow and pressure requirements are often designed with a number of different pump types.

Hydraulic actuators, both linear and rotary, also vary in price with the operating pressure. The lowest price hydraulic cylinder is usually suitable for maximum operating pressures of 500 to 750 psi, depending upon the size of the actuator. Medium and high-pressure hydraulic cylinders are constructed in operating pressure ranges of 2000 to 3000 psi, and 3000 psi and up.

Because of the trend toward operation at pressures as high as 2000 psi, a large number of hydraulic control valves are manufactured to operate at this pressure. Hence, valves suitable for 2000 or 3000 psi are the same price as equivalent valves for low-pressure operations. Hydraulic control valves for operating pressures over 3000 psi are less common, more specialized, and more expensive.

Combination Systems: A number of circuit applications require a comparison between combination air-oil or gas-oil circuits with their equivalent all-hydraulic circuits. When consistent and smooth control afforded by hydraulic circuits is necessary, but when relatively low forces are involved, air-oil circuits are often advantageous. They use air pressure over hydraulic oil in air-oil tanks as the power source. When the volume of oil required is relatively small, the air-oil circuit is often less expensive than the straight hydraulic system. As the volume of oil required per cycle and the momentary flow rates increase, the straight hydraulic circuit becomes more economical.

Hydraulic-pneumatic accumulators incorporated into high or medium-pressure hydraulic systems can be used to give hydraulic circuits the elasticity of a high-pressure pneumatic system. Accumulators also may be used to store hydraulic energy and release it at high momentary rates. For these applications, an economic comparison should be made between the cost of the accumulator and accessory controls and a straight hydraulic system with pumping capacity sufficient to give high momentary flow rates.

Components

Once the fluid and operating pressures for a system have been selected, the individual components and their connection in the circuit must be determined. Hence, the circuit designer must examine in detail all of the factors which affect the selection of specific components.

Sources of Power: If central compressed air or hydraulic supplies with sufficient flow and pressure capacities for a given circuit are available, the circuit can be connected to the central power source. If central power facilities are not available, the various power components must be analyzed.

Air and gas compressors must usually be selected on the basis of operating pressure and flow capacity. Other components selected along with the compressors are aftercoolers, storage tanks, and delivery lines. Each of these must insure an adequate supply of clean, dry, uncontaminated air. Pressure regulation is important to insure consistent control settings. Lubrication of operating valves and actuators is usually mandatory in a compressed-air system.

In hydraulic circuits, centrifugal pumps are not often suitable as power sources. However, they can be used for low-pressure fill applications. Positive-displacement pumps of the gear, vane, and piston types are more common for the high-pressure portions of the circuit. Positive-displacement pumps are available with either fixed or variable displacements. Currently, variable-displacement pumps of the vane type are available for operating pressures up to 1000 psi. For operating pressures over 1000 psi, variable-displacement pumps of the piston type are used.

Variable-displacement pumps have either unidirectional or reversing flow characteristics. The reversing-flow type is usually employed in high-horsepower circuits, where high speed and high-inertia movements are required along with smooth acceleration, deceleration, and reversal. This type of pump in a reversing circuit, while not the least expensive solution, is often best because of the simple control elements required.

Variable-displacement pumps are available with a number of built-in stroking operators. These stroke controls may be pressure-compensated to conserve horsepower by reducing the pump delivery as the pressure increases. Variable-displacement vane pumps can be manually controlled to establish maximum operating pressure, maximum flow, and minimum flow, or all three. In addition, they may be remotely controlled by means of hydraulic, pneumatic, servo, or electric controls. In a great number of circuit designs, particularly where variable-displacement pumps are expected to provide two or three different flow rates during a given cycle, multiple combinations of fixed-displacement pumps with remote unloading controls are often more economical.

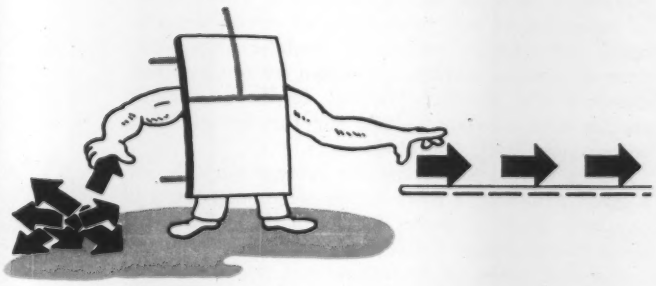
STORAGE: Hydraulic reservoirs are usually employed to store the bulk of the system and reserve fluid. In addition, they are used as mounting pads for pumps and drive motors. It is common practice to mount other accessory items such as accumulators, heat exchangers, inertia heaters, and control valves on the reservoir. They must have sufficient oil-storage capacity to prevent excessive flow rates within the reservoir itself and sufficient air-oil surface to

promote deaeration of the hydraulic fluid.

A reservoir with suitable baffling receives return oil from the operating circuit in one compartment and permits the pumping unit to draw supply oil from a separate compartment. This baffling inside of the reservoir promotes good natural circulation of the oil and serves as a settling basin for possible contaminants and dirt. In hydraulic circuits which require only intermittent use of full pump horsepower or capacity, the reservoir should dissipate all excess heat in the system to keep the operating temperature at a convenient level. However, when excessive heat is generated in the system, separate heat exchangers are required.

HEAT DISSIPATION: Heat exchangers are selected on the basis of the type of cooling medium, usually water or air, and capacity required to dissipate the amount of heat generated. Reservoirs should also be selected to suit the type of pump in service. Most vane and gear pumps are self-priming and can lift operating fluid from a reservoir. However, all centrifugal pumps and some piston pumps require flooded or supercharged suctions; hence, the reservoir should have an oil level higher than the level of the pump suction line.

Actuation: Actuators for hydraulic or pneumatic circuits are selected on the basis of the type of motion desired. Linear actuators or cylinders give straight-line motions and operate on several different principles. Diaphragm cylinders are used for relatively



low pressures and short working strokes. Piston-type cylinders are available in single or double-acting styles. Single-acting cylinders are returned with internal or external springs, by gravity, or by some other external force mechanism. Where positive-return characteristics are required, particularly when relatively high forces are required both on the in and out strokes of the cylinder, double-acting piston cylinders are advantageous.

Metallic piston-ring seals give the longest service life without maintenance on piston-type cylinders. When complete, dead-tight sealing is required without piston bypass, resilient piston cups or other seals are utilized. Precision feed cylinders and load carrying or hoist cylinders are examples of applications which require dead-tight sealing across the piston. Linear actuators produce rotary motions for limited strokes with rack and pinion or crank-type linkages. Rotary applications with limited stroke, where freedom from linkage backlash is desirable, require rotary actuators of the vane or piston type. These actuators are reversible and produce limited rotary motions in either direction. Because of high unbalanced radial loads on the operating components and bearings of vane and piston actuators, they are best suited for operation at pressures only up to 2000 psi.

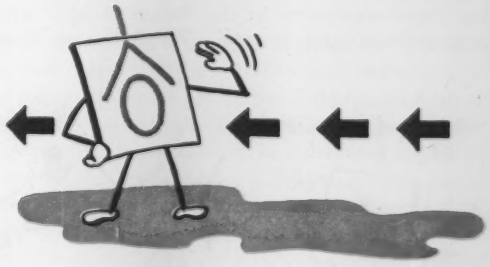
Air or hydraulically powered fluid motors may also be used to produce continuous rotary motions in either direction. These motors are available in gear, vane, and piston types, and in fixed and variable-displacement models. The combination of fixed or variable-displacement fluid motors together with fixed or variable-displacement hydraulic pumps leads to the design of constant-horsepower circuits or torque circuits with a high efficiency.

Rotary actuators are not suited for machine positioning. When rotary motions are required and accurate positioning is necessary, cylinder actuators with mechanical linkages are most effective. Rotary actuators or fluid motors for continuous motion can be controlled to produce dynamic braking and approximate positioning of moving loads. However, for accurate load positioning, external parking brakes, actuated by air, hydraulic, mechanical, or electrical means, should be employed.

Controls: Components for the control of a given circuit must be selected on the basis of flow capacity, pressure rating, function, and medium.

Most control valve manufacturers supply flow ratings and pressure-drop information on all of their products. This information simplifies the sizing of components. Determining valve size should be based not only on the pump flow capacity, but also on high momentary flow rates which are induced by accumulator action or by the high ratio which exists between piston and piston rod in hydraulic cylinders. For example, if a hydraulic cylinder with an 8-in. bore and 6-in. rod has 22 gpm of pump fluid forced into the rod-port end of the cylinder, approximately 50 gpm of oil is produced from the blind-end port of the cylinder.

Manual controls are most often used on various



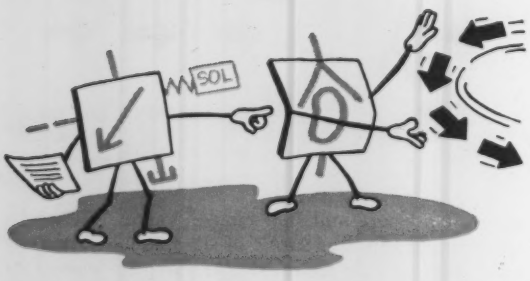
types of pressure and flow-control valves. Generally speaking, manual controls on directional valves are used only in the most simple circuits where the operator's control station is located relatively close to the machine or hydraulic control system. Manual directional controls may be used if positive interlocking is not required between various functions of the system. However, manual valves can be used when simple interlocking is designed into the circuit

through hydraulic sequence or pilot valves.

Piloted and directional control valves, utilizing either compressed air or hydraulic piloting, provide remote control when the control station is located reasonably close to pneumatic or hydraulic system. Here again, pilot and directional valves provide for positive position and functional interlocking. Where the operator's station is located at some distance from the machine, where the control circuit is fairly complex, or where positive interlocking with other electrical functions on a given machine or device are required, use of solenoid or motor controls on small pilot valves is common practice for economy. Piloting control is used on the main control valves, and stepped changes in pressure or flow control may be effected remotely when manual piloted or solenoid-controlled selector valves are used. Remote adjustments are made with electric, pneumatic, or hydraulic actuators on the control valves themselves.

Servo systems are practical for closed-loop control of pressure, flow, and direction or any combination of all three. In recent years, many commercial components with high performance and dependability ratings have been made available for servo-control systems. The many variables encountered in the design of a servo control circuit require more investigation than is required in the design of conventional pneumatic or hydraulic circuits. Because so many of the variables and constants involved are merely educated estimates at the start, even the most accurate performance equations do not give an exact prediction of system performance. Experienced circuit designers can usually set up conventional pneumatic and hydraulic control-circuits on paper with fairly accurate predictions of the system performance. It is usually necessary, however, to build a working model or mockup of a servo-control circuit to insure satisfactory performance.

Feedback: Elements of feedback circuits are the last items considered in the design of hydraulic or pneumatic control systems. When the motions of



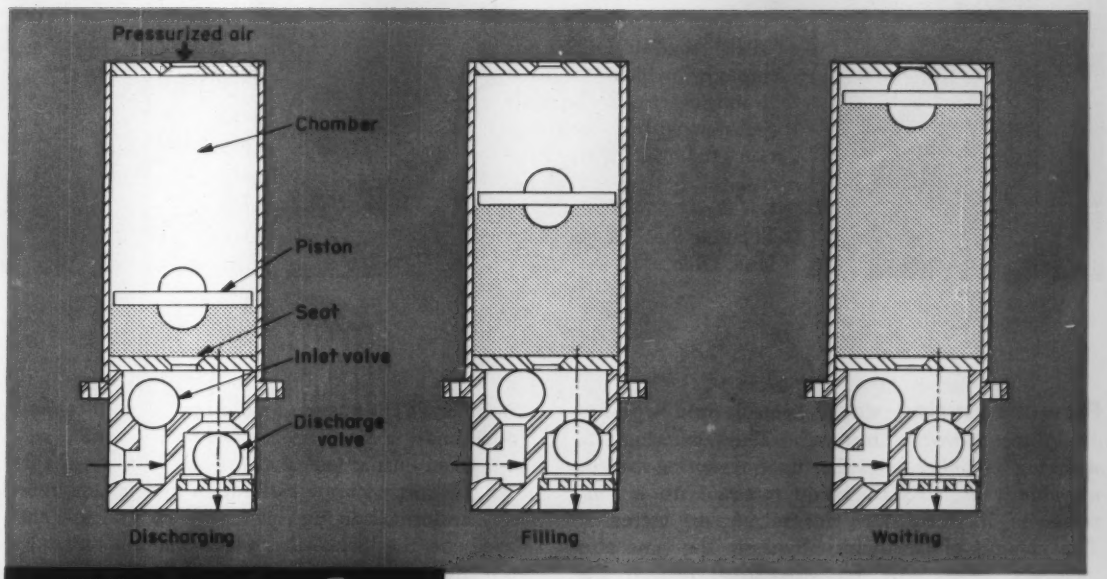
actuator components are physically independent of one another, and when actuator movements are not tied positively together or interspaced with other motions for a given installation, systems can be controlled by timer circuits, cam shaft-controls, or other suitable devices which produce starting signals only. In these circuits, control valves are provided with starting signals, telling when each motion is to take place. No provisions are made, however, to inform the control elements of the system that the motions have actually taken place as planned. This type of control circuit is satisfactory only where malfunctioning of any given control actuator through loss of pressure source, jamming of work parts, possible stoppages, or prolonged shutdown of the equipment are not important. In other applications, which involve exact physical position relationships between the various actuator elements and which require exact functional sequence, some system of feedback is required.

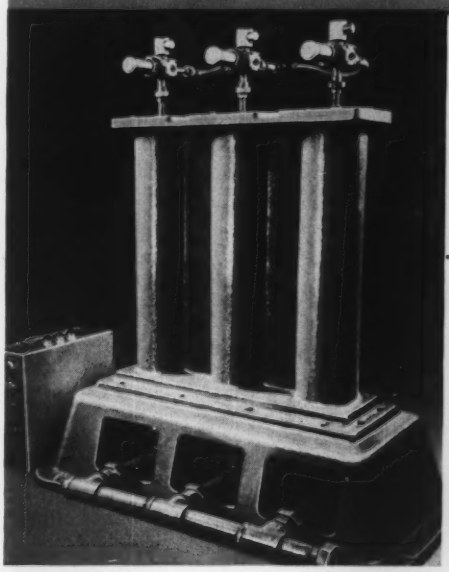
The simplest type of feedback relies on manually controlled valves and the senses of the operators. After the operator has initiated the forward stroke of the actuator, he visually determines that the actuator has traversed a sufficient portion of its available stroke, or has applied a required amount of force to the workload. He then initiates the next function in the proper sequence. In this manner, the operator initiates and carries through all of the functions in their proper sequence.

If more positive controls and feedback intelligence are required, either pilot controlled or solenoid-operated valves can be used as the basic control elements. Electrical limit switches, pilot valves, pressure switches, or pressure-sequence valves are most commonly used for this pilot control. The successful operation of the pilot-controlled circuit depends upon the accurate setting of predetermined positions or pressures which are sensed by the feedback elements. For these applications, feedback elements are set with constant values, and function is based on common on-off control elements.

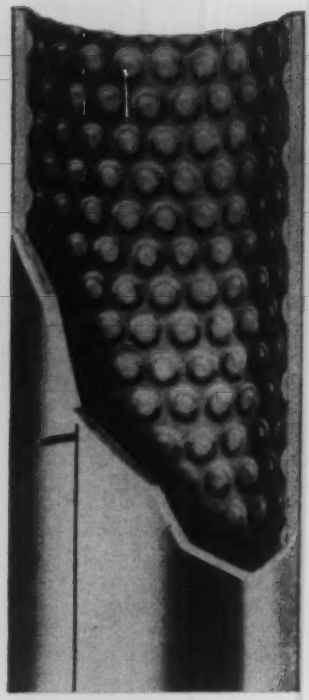
When the various constants become variable for a given situation, a more subtle means of control is required. Servo elements for feedback and control serve this purpose. Continuous automatic positioning of feed tables on a machine tool is one example of a closed-loop servo system application. The actual error between a desired condition and the actual condition is accurately measured. This feedback error is introduced into the control circuit, and causes a corrective control action. The corrective action is proportional to the amount of feedback signal. As correction takes place, the amount of feedback signal decreases, decreasing the amount of correction for the next instant. Feedback elements used for position controls are linear and variable differential transformers, potentiometers, or selsyns. Pressure and flow transducers also produce feedback. Servo-control systems may also be designed with mechanical feedback mechanisms. Such systems lend themselves to accurate programming with analog and digital input systems. Flexibility and accuracy of present day tape and punched-card controls for machine tools would not have been possible with on-off hydraulic control circuits.

scanning the field for *ideas*

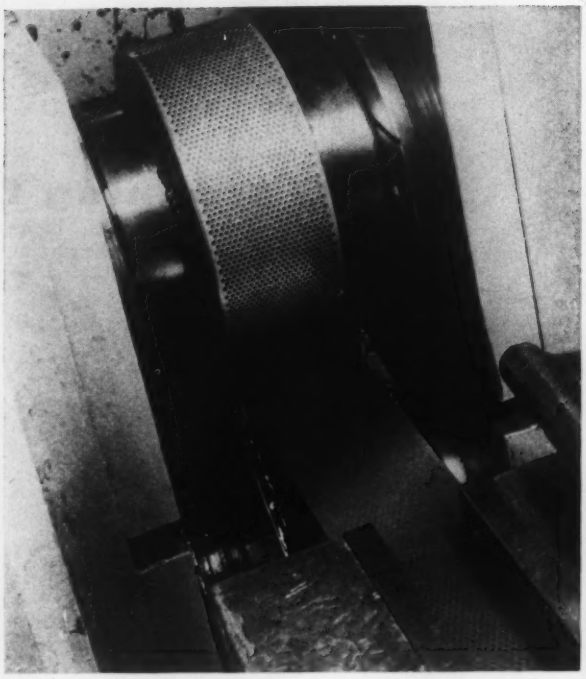




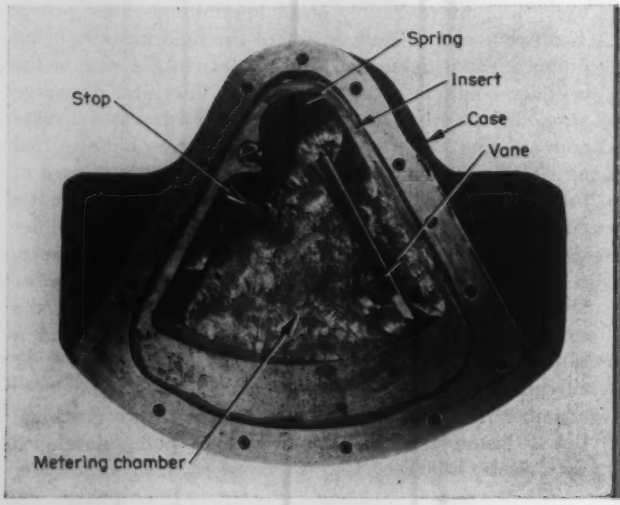
Free-floating piston doubles as check valve to control filling and emptying of an intermittent-action pump. The nylon piston floats on top of the fluid medium being pumped. Two nylon-ball check valves in the base of the cylinder containing the fluid act as inlet and discharge ports. In operation, three cylinders fill by gravity or power and are emptied in sequence by the force of pressurized air. During discharge, the pressurized air is introduced at the top of the cylinder, creating a downward force on the piston. The piston force on the fluid closes the inlet valve and opens the outlet valve. At the end of the stroke, the piston closes a port in the bottom of the chamber before all the fluid is discharged to seal the air in the cylinder. While one cylinder is discharging, a second is filling and a third is waiting ready to discharge. Air charges are automatically switched from chamber to chamber by a timing control system to insure continual flow. Piston principle employed in a pump developed by Crossley Machine Co., Trenton, N. J.

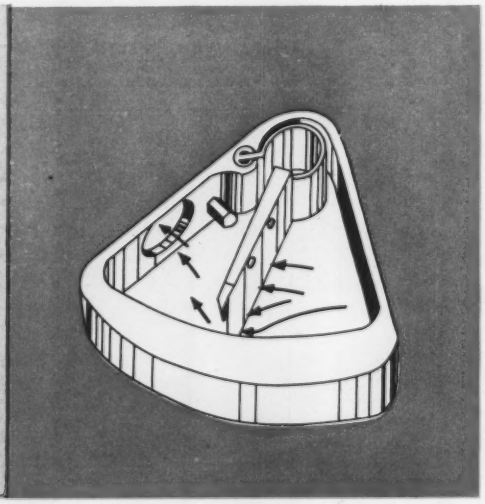


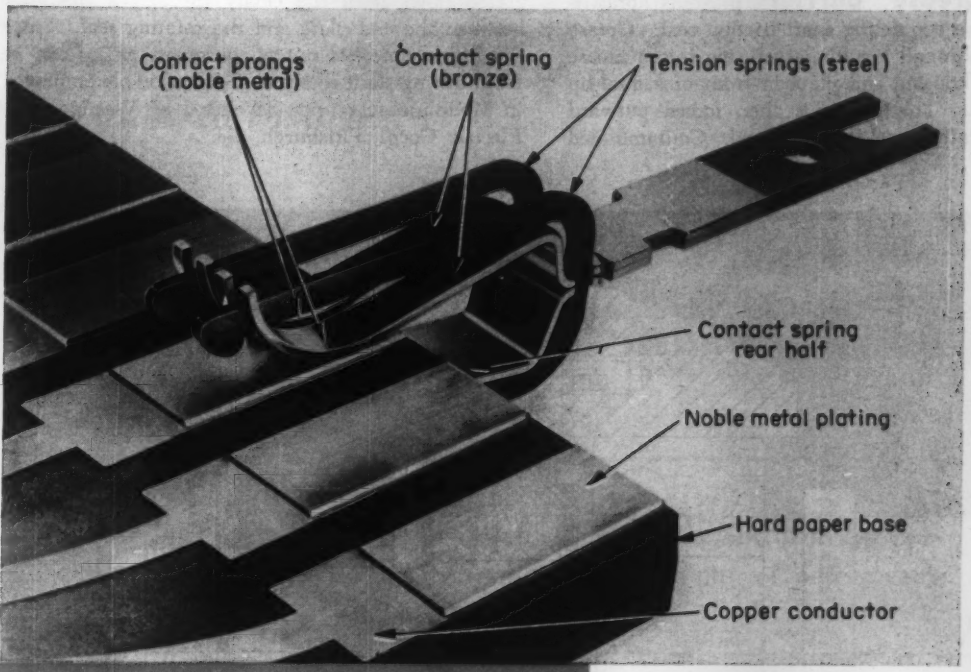
"Dimpled" interior surface of conduit reduces surface area and facilitates pulling through of electrical wires. Cold-rolled steel plate is dimpled with a special roller prior to tube forming. A low-friction material is painted on tube interior. The paint and the dimpled surface combine to produce a "slick" conduit interior through which multiple strands of wire can be easily pulled. Surface construction employed in the Electrunite E.M.T. developed by Steel and Tubes Div., Republic Steel Corp., Cleveland, Ohio.

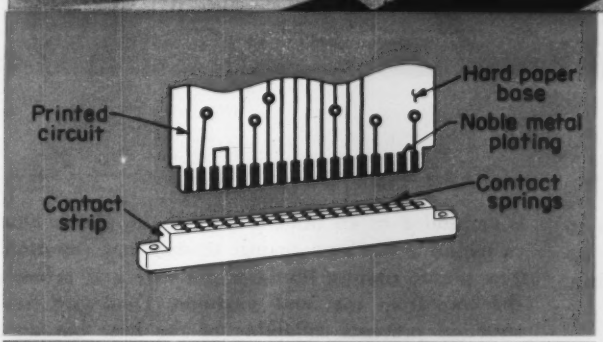


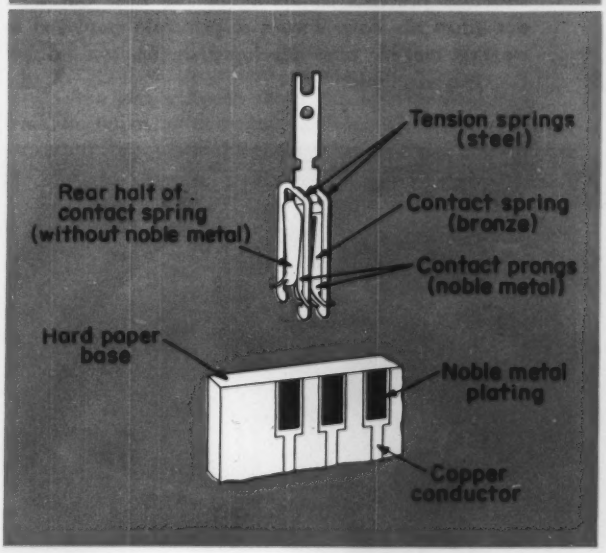
Flow-measuring vane controls fluid bypass to give direct flow-rate readings. Fluid entering the metering chamber impinges upon a spring-loaded, movable vane. As the vane rotates with an increase in the flow, the clearance space increases. The amount of flow which bypasses the vane also increases, minimizing pressure drop through the flowmeter. The vane doubles as a pointer and travels under a transparent plastic cover which permits visual inspection of the flow. An adjustable insert permits accurate calibration and insures relatively uniform scale increments. Vane principle employed in the Seico flowmeter manufactured by Seico Instrument Div., Eclipse Fuel Engineering Co., Rockford, Ill.





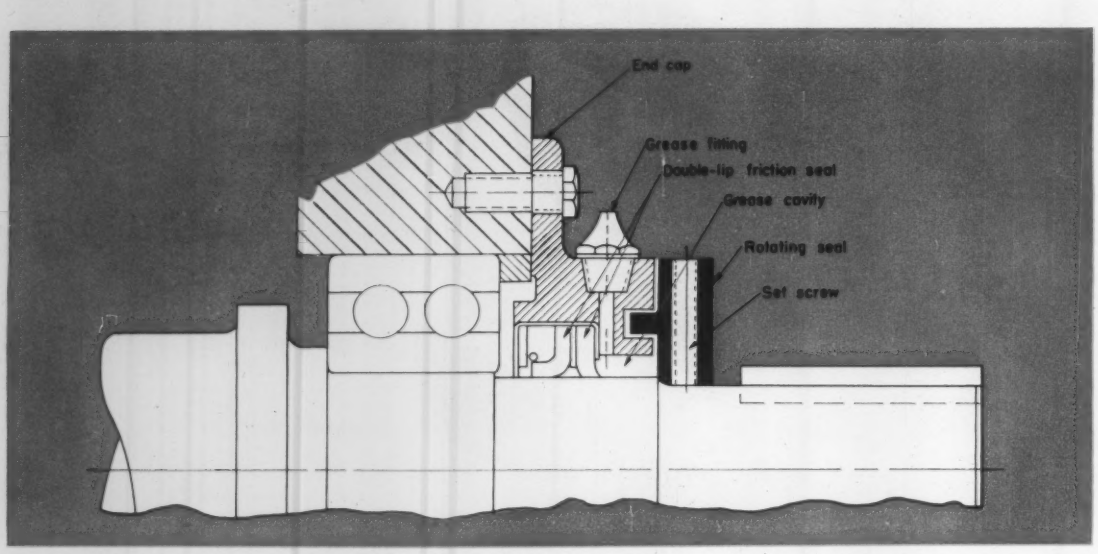




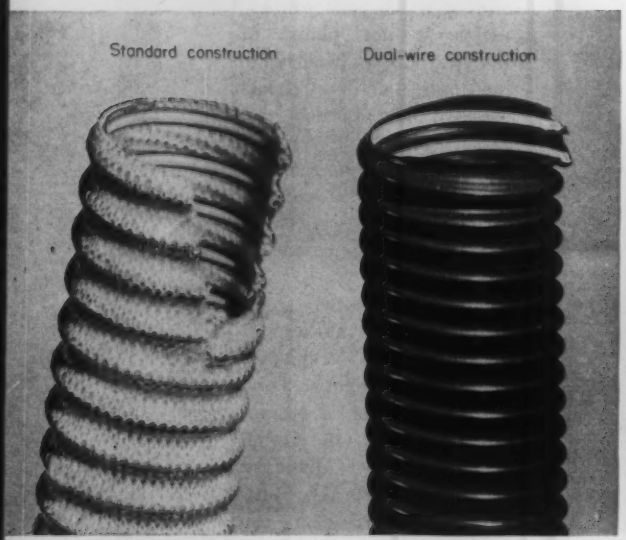


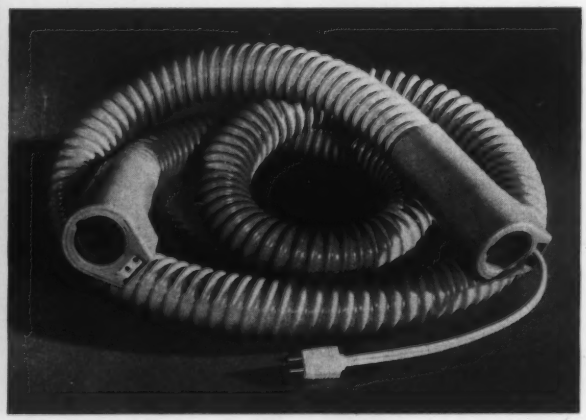
Double springs insure positive electrical contact in plug-in printed circuit connector. The front half of a bronze contact, which is plated with a noble metal, is slotted longitudinally to form two prongs. The rear half of the bronze contact, which is not plated or slotted, is spot welded to the front half. Contact pressure is produced by two steel spring-clips which wrap around the contact prongs to insure uniform spring rigidity. Positive contact of the connector with the noble-plated contact on the printed circuit board prevents buildup of oxidation and premature aging of the paper-based board. Contact construction employed in design developed by Standard Elektrik Lorenz AG, Stuttgart, Germany.

Flowing-grease "barrier" prevents abrasive material from contacting shaft friction seal. Grease is pumped through a stationary fitting into a grease cavity in a housing end plate in front of a dual-lip friction seal. The grease is then forced outward toward a rotating steel labyrinth seal. Contaminated grease flows from the cavity through a clearance between the end plate and the rotating seal. Since the fitting does not rotate, the grease cavity can be filled during shaft rotation. Seal principle employed in Moduline gear units developed by Westinghouse Electric Corp., Pittsburgh, Pa.



Dual-wire construction permits air hose to double as current carrier. A spiral core, made up of two strands of steel wire with a copper coating, is embedded as an integral part of the plastic hose to reinforce the hose against tension and vibration. The plastic coating insulates the wire and protects the core from rust and corrosion. Dual-wire construction prevents collapsing of the hose but does not affect air flow. Two-wire principle employed in vacuum cleaner hose developed by Dayton Rubber Co., Dayton, Ohio.





Prompt action is a must to insure

PROTECTION AGAINST PATENT INFRINGEMENT

> "Equity frowns on stale demands. She turns her back upon a litigant who has been guilty of unreasonable delay in filing suit."
>
> *Federal appellate court*

ALBERT WOODRUFF GRAY
Forest Hills, N. Y.

DELAY can cause a patent owner to lose his rights to protection against infringement. If the owner knew about the infringement and had the opportunity to take action, but failed to do so promptly, the infringer might reasonably assume that the rights are worthless or the patent abandoned.

In a Federal court in California, suit was recently brought for infringement of a patent for a system of photography. The system recorded visual actions in the foreground superimposed on a stationary, pictorial background. The patent had been issued in 1937.

In 1939, after seeing the motion picture "Snow White and the Seven Dwarfs," the patentee determined that the process used in that production was an infringement of his patent.

Two actions were brought, but both were abandoned and discontinued during the succeeding four years. For the next ten years, no claim whatever was asserted by the patentee until an infringement suit was brought in 1953. The district court dismissed the action on grounds of delay, and made the comment:

"During these many years the owner of this patent has not exploited his alleged invention. These alleged infringers have, on the other hand, invested millions of dollars of time, effort, and capital.

"This venture has paid handsome rewards, not only in profit but in entertainment to millions of children and adults the world over. Whatever claim the patentee may have had for the originating or perfecting of this new form of art, these alleged infringers were responsible for making it a commercial success.

"Patentee failed for over a decade to assert his alleged claim. At this late hour he demands that

these users account to him for the profits of the venture. This plea is not one calculated to find sympathetic reception in a court of equity." It was the judgment of the court that the patentee had no case because of his unreasonable delay.[1]

Two years later, on appeal by the owner of this patent, the decision of the lower court was sustained. It was said of the consequences of delays of this character, "It is a general rule that one cannot have knowledge of an alleged infringement and then stand idly by while the infringer embarks on a costly expansion program."

Mere passage of time cannot constitute unreasonable delay, "but if the passage of time can be shown to have lulled the alleged infringer into a false sense of security and he acts in reliance thereon," the patentee's delay may be found unreasonable.[2] Precedent for the finding of unreasonable delay in this case was traced back more than a century.

Not always, however, does the court bestow immunity on the infringer. While no legal principle can ever be applied with mathematical precision, due to the infinite variations of factual circumstances, the abstract principle remains unchanged.

Many years ago, an infringement was charged of a patent involving automobile spark plugs. This patent had been granted a year prior to the death of the inventor and was assigned to a manufacturer who brought action eight years later.

At that time, infringements by various manufacturers covered a period of eight years, and the device had been sold in large quantities throughout the country and in the open market. Apparently, none of the intermediate holders of the patent had known of these infringements.

In a suit brought by the last patent owner, the defense of delay was interposed. The Court granted an injunction against further infringements, but it denied an accounting of the profits accruing from these infringements.

"During this long period," said the Court, "the successive owners treated this patent as if it were of no importance whatever, of no use to anyone. Apparently they made no effort even to ascertain if there were any infringements of it, or to caution or warn anybody against infringement.

"The infringement was not an act done in a corner. Had the owner taken the trouble to send a competent man to the warerooms of a few dealers in automobile supplies of that sort, or to any of the periodical automobile shows . . . there can be little doubt that infringement would have been discovered years ago."

An announcement could have been placed in some of the trade papers to the effect that the owners of this patent would prosecute infringements, the Court observed. Such an announcement would have warned the trade that this patent was not regarded by its owners as a thing of no account, and infringing manufacturers could have modified their devices long ago to avoid infringement.

"Where owners have remained thus supine for many years, shutting their eyes to what was going on in the art to which the patent belonged and thus leading others to suppose that they intended to make no claim that their patent demanded a portion of that art, it seems to us inequitable that they should make at this late date a necessity of being granted an accounting for damages and profits during their long period of inaction."[3]

Not every delay, however, will operate to deprive a patent owner of his monopoly and his right to protection against infringement. For nine years a patent owner protested, verbally and in writing, against the infringement of oil well equipment patents.

Ultimately, suit brought by the patentee was dismissed on the ground of delay. A lesser point the court made was that the patent owner had carried on the dispute without retaining an attorney for that purpose.

The Federal Court of Appeals reversed the decision on grounds that the patent owner had indeed given due notice of his interest and intentions, even to the extent of making "somewhat of a nuisance of himself. It cannot be said that the infringer had no notice and did not expect trouble in view of the action of the patentees that required the infringer to keep an attorney employed for over nine years." Further, that appellate court said that the elements necessary to establish unreasonable delay were:

"1. An alleged invasion by the infringer of the patentee's right of which the patentee has had knowledge and an ample opportunity to establish the same in the proper form.

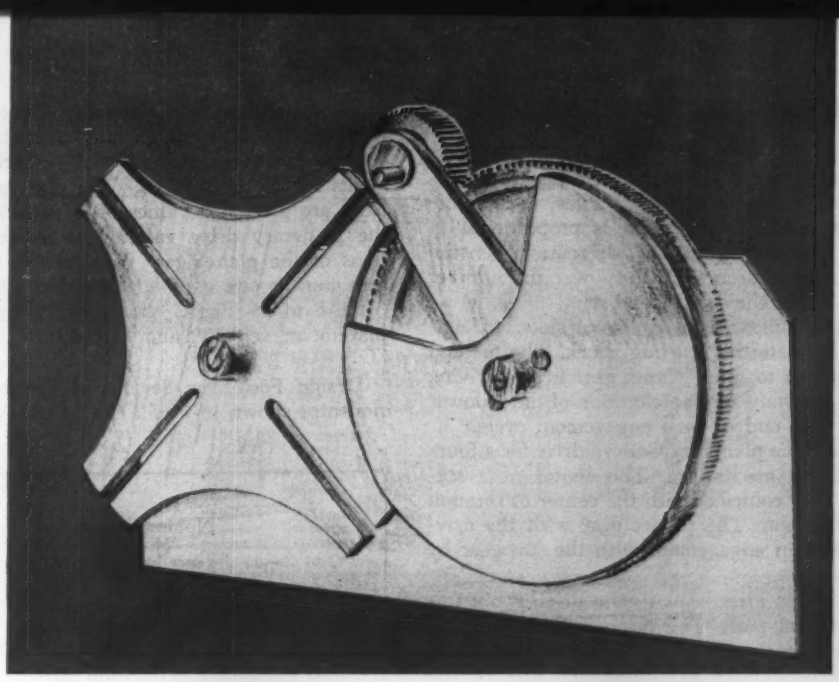
"2. A delay of the patent owner in the assertion of such rights by reason of which the infringer has good reason to believe that the alleged rights are worthless or have been abandoned.

"3. Changes in the condition or relation of the parties during the period of delay making it unjust to the infringer to permit the patent owner to recover."[4]

Underlying this rule of law that would forfeit a patent monopoly because of delay is a great maxim of justice which declares that he who was silent when conscience required him to speak, shall not be permitted to speak when conscience requires him to be silent.[5]

REFERENCES

1. Whitman v. Walt Disney Productions, 148 *F. S.* 37, California, January 16, 1957.
2. Whitman v. Walt Disney Productions, 263 *Fed. 2d* 229, California, December 27, 1958.
3. A. R. Mosler & Co. v. Lurie, 209 *Fed.* 364, New York, November 11, 1913.
4. Shaffer v. Rector Well Equipment Co., 155 *Fed. 2d* 344, Texas, May 3, 1946.
5. Searchlight Horn Co. v. Victor Talking Machine Co., 261 *Fed.* 395, New Jersey, October 23, 1919.



A unique design innovation:

Planetary-Genevas

. . . eliminate shock during indexing

LEIF ARNESEN
Senior Development Engineer
Aeronautical Division
Minneapolis-Honeywell Regulator Co.
Minneapolis, Minn.

SMOOTH conversion of continuous motion to intermittent motion is a desirable feature in most indexing operations. Conventional Geneva drives are commonly used to perform indexing functions. However, Geneva drives must often be modified to give the desired smoothness.

In a standard Geneva drive with straight slots, Fig. 1, a shock is experienced by the follower at the instant the driving pin engages a slot. The driver rotates with constant velocity and, thus, has constant acceleration $R_1\omega^2$ (see Nomenclature) toward the center of rotation. At the instant of engagement, this acceleration is applied to the follower. The resulting shock may be undesirable or even destructive, especially if the driven mass is large. Accelera-

tion transferred to the follower at the instant of engagement is $\beta'' = \omega^2 \text{ cotan } \alpha_{max}$. Thus, the magnitude of this sudden acceleration is proportional to cotan α_{max}. Therefore, since α_{max} decreases when the number of slots is decreased, the fewer the number of slots, the higher the acceleration step.

Various alterations, such as curved slots, are employed to eliminate this starting shock. The method presented here is to use a planet gear in the driving mechanism to obtain zero acceleration of the follower at the start and end of each engagement cycle.

Fig. 2 shows the planetary Geneva drive for a four-station indexing mechanism. The center of a stationary sun gear coincides with the center of rotation of the driving arm. The planet gear with the driving pin is held in engagement with the sun gear by the driving arm.

Because of this arrangement, the driving pin follows a trochoidal path. The mechanism is designed to impart no acceleration to the follower pin in a direction perpendicular to the center line of the follower slot at the moment of engagement.

In the simplest planetary Geneva drive, the driving-pin center is on the driving-arm center line between the centers of the planet gear and the sun gear at the moment of engagement. This location of the driving pin at the start of engagement is not necessary to give zero follower acceleration. In addition, a zero total acceleration is not necessary as long as the component of driving-pin acceleration perpendicular to the follower slot direction is zero.

Displacement, velocity, and acceleration characteristics of standard and planetary Geneva drives are given in Table 1 for 2.5-deg increments of input angle α for drives with $N = 3$, 4, and 5 deg increments for $N = 6$ drives. The planetary characteristics are given for values of $n = 1$, 2, and 3. For the planetary drive values, the number of revolutions of the planet gear with respect to the driving arm during one complete engagement, n, is varied from 1 to 3. Fig. 3 shows typical curves for displacement, velocity, and acceleration characteristics.

Design Formulas: Several of the geometric relationships shown in Fig. 2 can be used to obtain zero

Nomenclature

- C = Center distance between driving arm and follower
- N = Number of slots in follower
- n = Number of revolutions of planet gear with respect to driving arm during one complete engagement of the driving pin
- R = Pitch radius of sun gear, in.
- R_1 = Radius of driver, in.
- r = Pitch radius of planet gear, in.
- r_1 = Driving pin eccentricity, in.
- α = Driver displacement, deg
- α_{max} = Angle α at start of engagement, deg.
- β = Follower displacement, deg.
- β' = Follower velocity, deg per sec
- β'' = Follower acceleration, deg per sec^2
- ω = Angular velocity of driving arm, deg per sec

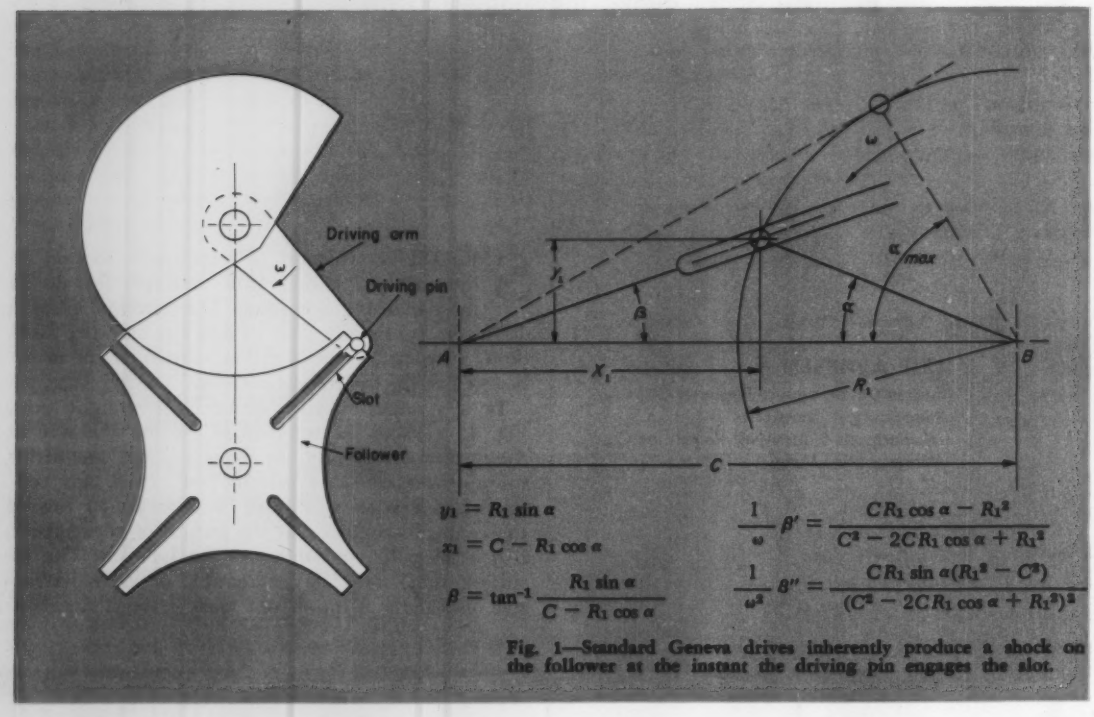


Fig. 1—Standard Geneva drives inherently produce a shock on the follower at the instant the driving pin engages the slot.

Table 1—Geneva Drive Characteristics

Driver Displacement	Standard Geneva			Planetary Geneva								
				$n = 1$			$n = 2$			$n = 3$		
α	β	β'/ω	β''/ω^2	β	β'/ω	β''/ω^2	β	β'/ω	β''/ω^2	β	β'/ω	β''/ω^2
Number of Slots, N = 3												
0.0	0.00000	6.46410	0.00000	0.00000	10.32139	0.00000	0.00000	6.00238	0.00000	0.00000	7.07738	0.00000
2.5	15.65478	5.87828	24.58880	23.83551	8.15008	80.18887	14.73092	5.67717	14.36379	16.86910	6.14013	37.42384
5.0	28.80455	4.59369	31.33366	39.90328	4.82746	63.82056	27.94701	4.83093	23.24957	30.03016	4.38945	37.90555
7.5	38.64303	3.31480	26.32029	49.06068	2.68981	36.33056	38.69099	3.74977	25.28414	39.17472	3.02689	24.33286
10.0	45.62630	2.32403	19.18934	54.14584	1.49595	20.06540	46.71966	2.69280	22.63206	45.62630	2.20783	14.25214
12.5	50.50228	1.61844	13.45918	56.97433	0.82969	11.36191	52.29660	1.80234	18.04265	50.46798	1.69570	10.05276
15.0	53.89413	1.12406	9.45918	58.52588	0.44872	6.55130	55.90663	1.12051	13.26589	54.18195	1.28084	9.26240
17.5	56.24231	0.77403	6.76320	59.35096	0.22921	3.74997	58.06412	0.63608	9.06317	56.88201	0.88134	8.94207
20.0	57.84485	0.52120	4.94227	59.75413	0.10562	2.05242	59.22562	0.31786	5.66106	58.61730	0.51712	7.53707
22.5	58.90311	0.33448	3.69252	59.92753	0.04063	1.01282	59.76208	0.13002	3.08477	59.54009	0.23891	5.10572
25.0	59.55523	0.19356	2.81689	59.98662	0.01106	0.40114	59.95472	0.03698	1.31162	59.90744	0.07396	2.50907
27.5	59.89782	0.08506	2.19009	59.99922	0.00127	0.09001	59.99731	0.00437	0.30712	59.99431	0.00919	0.63882
30.0	60.00000	0.00000	1.73205	60.00000	0.00000	0.00000	60.00000	0.00000	0.00000	60.00000	0.00000	0.00000
Number of Slots, N = 4												
0.0	0.00000	2.41421	0.00000	0.00000	3.77780	0.00000	0.00000	2.17279	0.00000	0.00000	2.69279	0.00000
2.5	5.99778	2.36920	2.03130	9.29118	3.59677	7.96688	5.43088	2.17120	0.10397	6.64334	2.58812	4.60802
5.0	11.77728	2.24219	3.70737	17.74421	3.13119	12.70080	10.84726	2.15872	0.54597	12.80218	2.31929	7.30504
7.5	17.15762	2.05401	4.81635	24.84680	2.54392	13.68578	16.19929	2.11593	1.50251	18.18640	1.98589	7.62352
10.0	22.01800	1.83053	5.33527	30.47760	1.97068	12.34254	21.38342	2.02128	2.88553	22.75348	1.67708	6.36356
12.5	26.30076	1.59540	5.37583	34.76938	1.47876	10.15438	26.25183	1.86262	4.36965	26.63058	1.43736	4.62477
15.0	30.00000	1.36603	5.09808	37.95332	1.08439	7.95897	30.64633	1.64429	5.56028	30.00000	1.26945	3.21794
17.5	33.14467	1.15300	4.64794	40.26613	0.77957	6.07456	34.43950	1.38565	6.19063	33.01162	1.14579	2.53724
20.0	35.78290	0.96136	4.13180	41.91292	0.53888	4.55887	37.56301	1.11305	6.20860	35.73959	1.03612	2.59707
22.5	37.97042	0.79241	3.61589	43.05941	0.37693	3.37252	40.01382	0.85111	5.72939	38.17999	0.91234	3.12071
25.0	39.76317	0.64528	3.13579	43.83559	0.25069	2.45343	41.84251	0.61765	4.93449	40.27953	0.76305	3.69724
27.5	41.21338	0.51801	2.70698	44.34224	0.15978	1.74410	43.13423	0.42258	3.99470	41.97855	0.59413	3.97594
30.0	42.36780	0.40825	2.33321	44.65715	0.09611	1.19887	43.99033	0.26926	3.03839	43.24813	0.42284	3.79690
32.5	43.26723	0.31363	2.01209	44.84011	0.05328	0.78377	44.51435	0.15641	2.15081	44.10739	0.26893	3.19939
35.0	43.94675	0.23197	1.73841	44.93662	0.02618	0.47430	44.80263	0.07978	1.38530	44.61999	0.14737	2.34682
37.5	44.43625	0.16133	1.50609	44.98058	0.01061	0.25288	44.93839	0.03327	0.77458	44.87705	0.06488	1.44205
40.0	44.76115	0.10003	1.30912	44.99629	0.00302	0.10658	44.98807	0.00966	0.33758	44.97557	0.01957	0.67044
42.5	44.94298	0.04665	1.14202	44.99977	0.00036	0.02523	44.99927	0.00117	0.08144	44.99848	0.00243	0.16799
45.0	45.00000	0.00000	1.00000	45.00000	0.00000	0.00000	45.00000	0.00000	0.00000	45.00000	0.00000	0.00000
Number of Slots, N = 5												
0.0	0.00000	1.42592	0.00000	0.00000	2.20787	0.00000	0.00000	1.26139	0.00000	0.00000	1.60670	0.00000
2.5	3.55427	1.41332	0.57361	5.47663	2.15658	2.30937	3.15786	1.26656	−0.22745	3.98534	1.56939	1.66851
5.0	7.04638	1.37652	1.10247	10.70561	2.01309	4.16236	6.33950	1.27960	−0.34296	7.79290	1.46779	2.88456
7.5	10.41898	1.31830	1.55022	15.48713	1.80383	5.30381	9.55669	1.29353	−0.25650	11.29220	1.32783	3.41082
10.0	13.62342	1.24275	1.89454	19.69665	1.56069	5.73241	12.79959	1.29835	0.07772	14.42546	1.17974	3.28330
12.5	16.22210	1.15458	2.12851	23.28587	1.31158	5.61224	16.03187	1.28335	0.64347	17.20456	1.04766	2.72106
15.0	19.38976	1.05852	2.25831	26.26596	1.07586	5.15182	19.19257	1.23998	1.35972	19.68826	0.94458	1.99913
17.5	21.91179	0.95881	2.29880	28.68554	0.86436	4.52735	22.20471	1.16433	2.10099	21.95310	0.87195	1.36095
20.0	24.18369	0.85894	2.26889	30.61164	0.68140	3.85848	24.98866	1.05820	2.73616	24.06714	0.82210	0.97536
22.5	26.20857	0.76155	2.18783	32.11661	0.52727	3.21422	27.47601	0.92854	3.16782	26.07176	0.78202	0.91698
25.0	27.99508	0.66850	2.07287	33.27042	0.40005	2.62815	29.62007	0.78536	3.35368	27.97357	0.73765	1.15995
27.5	29.55567	0.58095	1.93811	34.13691	0.29689	2.11249	31.40045	0.63932	3.30412	29.74712	0.67803	1.59116
30.0	30.90493	0.49950	1.79432	34.77230	0.21466	1.66801	32.82215	0.49979	3.06429	31.34686	0.59840	2.04978
32.5	32.05846	0.42438	1.64923	35.22514	0.15035	1.29025	33.91078	0.37381	2.69334	32.72417	0.50101	2.38310
35.0	33.03205	0.35552	1.50805	35.53668	0.10119	0.97291	34.70627	0.26581	2.24918	33.84357	0.39371	2.49377
37.5	33.84108	0.29267	1.37404	35.74160	0.06467	0.70962	35.25663	0.17788	1.78081	34.69322	0.28700	2.35835
40.0	34.50013	0.23548	1.24904	35.86868	0.03856	0.49472	35.61259	0.11020	1.32639	35.28751	0.19093	2.01644
42.5	35.02285	0.18353	1.13387	35.94139	0.02086	0.32345	35.82348	0.06151	0.91440	35.66301	0.11291	1.54534
45.0	35.42179	0.13639	1.02871	35.97846	0.00975	0.19191	35.93406	0.02948	0.56556	35.87030	0.05664	1.03512
47.5	35.70843	0.09362	0.93327	35.99426	0.00358	0.09686	35.98222	0.01102	0.29440	35.96425	0.02191	0.57084
50.0	35.89318	0.05481	0.84704	35.99920	0.00081	0.03542	35.99749	0.00253	0.10985	35.99487	0.00514	0.22127
52.5	35.98546	0.01958	0.76936	35.99998	0.00004	0.00479	35.99995	0.00013	0.01501	35.99990	0.00027	0.03081
54.0	36.00000	0.00000	0.72654	36.00000	0.00000	0.00000	36.00000	0.00000	0.00000	36.00000	0.00000	0.00000
Number of Slots, N = 6												
0.0	0.00000	1.00000	0.00000	0.00000	1.53846	0.00000	0.00000	0.87500	0.00000	0.00000	1.13402	0.00000
5.0	4.96228	0.97751	0.50737	7.53895	1.44800	1.98607	4.40383	0.89169	−0.34777	5.54097	1.05880	1.59829
10.0	9.70648	0.91407	0.92593	14.24372	1.21732	3.12507	8.94527	0.92450	−0.31780	10.42922	0.89003	2.04631
15.0	14.05191	0.82008	1.20272	19.62123	0.93135	3.29221	13.60492	0.93099	0.25454	14.46439	0.73311	1.43929
20.0	17.87799	0.70848	1.33198	23.58368	0.65991	2.86711	18.14078	0.87004	1.16189	17.87799	0.64407	0.64536
25.0	21.12724	0.59109	1.34165	26.30223	0.43673	2.23676	22.17458	0.73206	1.94105	20.98872	0.60375	0.40486
30.0	23.79398	0.47663	1.27173	28.04418	0.26909	1.61678	25.37942	0.54546	2.24458	23.89611	0.55241	0.86256
35.0	25.90736	0.37038	1.15871	29.07720	0.15179	1.08978	27.62335	0.35498	2.05075	26.41912	0.44686	1.53350
40.0	27.51575	0.27487	1.02917	29.63062	0.07563	0.67416	28.98364	0.19646	1.55058	28.28868	0.29705	1.79959
45.0	28.67505	0.19074	0.89968	29.88597	0.03100	0.36590	29.67044	0.08685	0.96244	29.39550	0.15052	1.47199
50.0	29.44146	0.11758	0.77912	29.97808	0.00889	0.15638	29.93446	0.02625	0.44921	29.87233	0.04991	0.81259
55.0	29.86745	0.05439	0.67136	29.99867	0.00107	0.03732	29.99595	0.00326	0.11275	29.99183	0.00653	0.22363
60.0	30.00000	0.00000	0.57735	30.00000	0.00000	0.00000	30.00000	0.00000	0.00000	30.00000	0.00000	0.00000

acceleration at the start of follower motion.

The center distance between driving arm A and follower B is

$$C = \frac{1}{\cos \alpha_{max}} \left[1 + \frac{N-2}{2nN} - \frac{(N-2)^2}{2nN(2nN+N-2)} \right] R \quad (1)$$

At the start of engagement, the angle between the center line of the driving arm and center line AB is

$$\alpha_{max} = \frac{N-2}{2N} \pi \quad (2)$$

In addition, the pitch radius of the planet gear is

$$r = \frac{N-2}{2nN} R \quad (3)$$

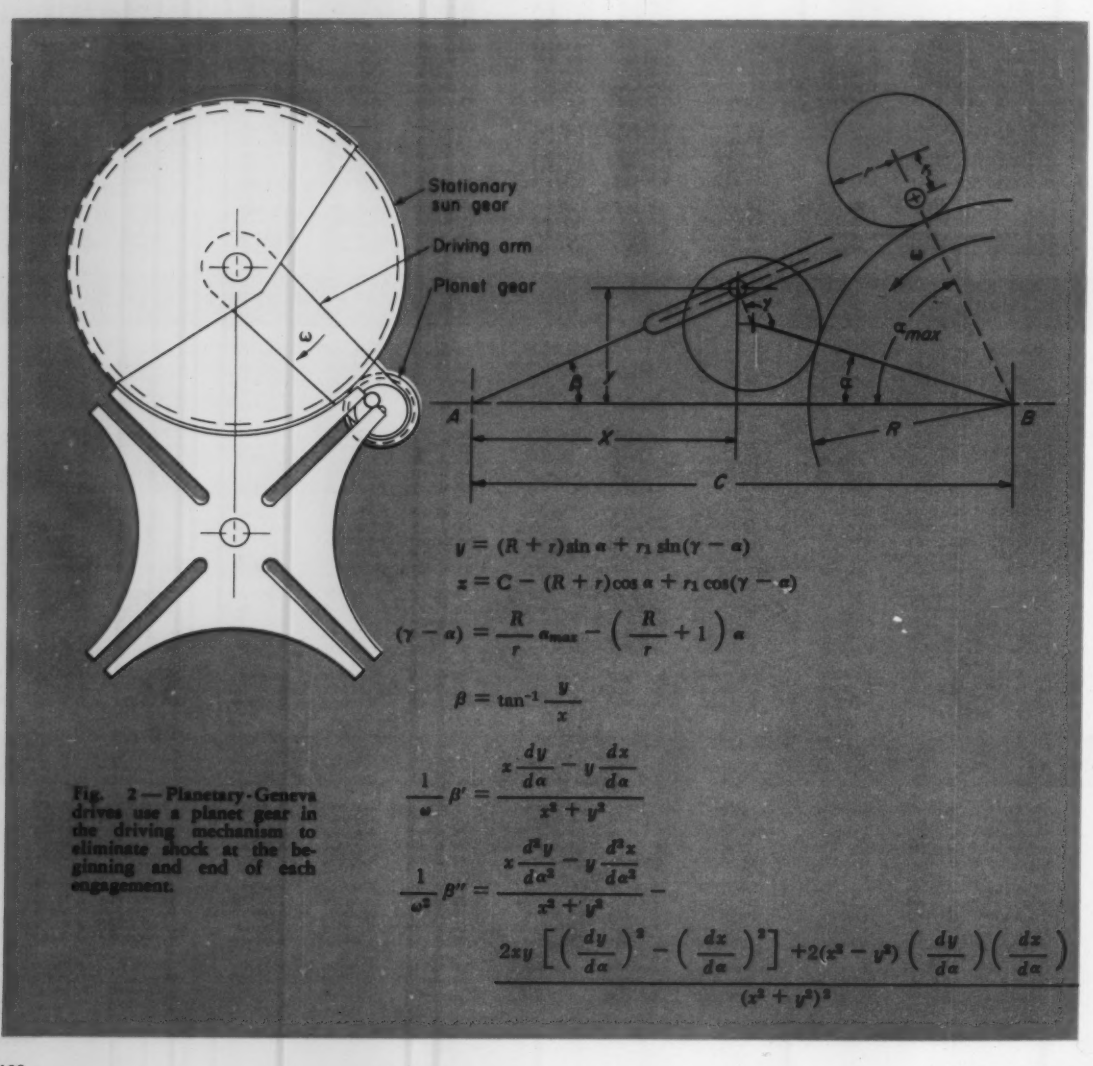
If the acceleration perpendicular to the center line of the follower slot is set equal to zero at the moment of engagement, the driving pin eccentricity can be determined:

$$(R+r)\omega^2 - r_1 \left(\frac{R}{r} + 1 \right)^2 \omega^2 = 0$$

$$r_1 = \frac{(N-2)^2}{2nN(2nN+N-2)} R \quad (4)$$

Recommendations: Curves similar to those in Fig. 3 illustrate the motion of the follower in the first half of the engagement. Curves describing the second half are symmetrical about the point $\alpha = 0, \beta = 0$ for the displacement and acceleration characteristics, and are symmetrical about the axis $\alpha = 0$ for the velocity characteristics.

At the start of engagement, planetary drives with $n = 1$ are slower than the other planetary and standard drives, and must therefore move faster during the latter part of the half engagement. This is generally true for the drives investigated. The drives with $n = 2$ and $n = 3$, together with the standard drive, give generally similar displacement characteristics. Velocity characteristics show that the velocity of the drives with $n = 1$ is lower



$$y = (R+r)\sin\alpha + r_1 \sin(\gamma - \alpha)$$

$$x = C - (R+r)\cos\alpha + r_1 \cos(\gamma - \alpha)$$

$$(\gamma - \alpha) = \frac{R}{r}\alpha_{max} - \left(\frac{R}{r} + 1 \right)\alpha$$

$$\beta = \tan^{-1}\frac{y}{x}$$

$$\frac{1}{\omega}\beta' = \frac{x\frac{dy}{d\alpha} - y\frac{dx}{d\alpha}}{x^2+y^2}$$

$$\frac{1}{\omega^2}\beta'' = \frac{x\frac{d^2y}{d\alpha^2} - y\frac{d^2x}{d\alpha^2}}{x^2+y^2} - \frac{2xy\left[\left(\frac{dy}{d\alpha}\right)^2 - \left(\frac{dx}{d\alpha}\right)^2\right] + 2(x^2-y^2)\left(\frac{dy}{d\alpha}\right)\left(\frac{dx}{d\alpha}\right)}{(x^2+y^2)^2}$$

Fig. 2 — Planetary-Geneva drives use a planet gear in the driving mechanism to eliminate shock at the beginning and end of each engagement.

Design Example

Assume the problem is to design an indexing table with four stations, $N = 4$. Center distance C should be approximately 6 in. and the characteristics of a drive with $n = 2$ are desired.

1. Determine the follower displacement at start of engagement. From Equation 2,

$$\alpha_{max} = \frac{4-2}{2(4)}\pi = 45 \text{ deg}$$

2. Express center distance C, planet-gear pitch radius r, and driving-pin eccentricity r_1 in terms of R. From Equation 1,

$$C = \frac{1}{\frac{\sqrt{2}}{2}}\left\{1 + \frac{4-2}{2(2)(4)} - \frac{(4-2)^2}{2(2)(4)[2(2)(4)+4-2]}\right\}R$$

$$= \frac{10\sqrt{2}}{9}R$$

From Equation 3,

$$r = \frac{4-2}{2(2)(4)} = \frac{1}{8}R$$

From Equation 4,

$$r_1 = \frac{(4-2)^2}{2(2)(4)[2(2)(4)+4-2]}R = \frac{1}{72}R$$

3. Using the required center distance, $C = 6$ in., determine an approximate value of R:

$$R = \frac{9C}{10\sqrt{2}} = \frac{9(6)}{10\sqrt{2}} = 3.82 \text{ in.}$$

4. Select a suitable diametral pitch and determine the exact number of teeth and pitch diameter of the stationary sun gear. Assume a diametral pitch of 16 and $R = 3.75$ in. Then, the sun-gear pitch diameter is $2R = 7.5$ in., and the number of teeth is $7.5(16) = 120$.

5. Determine pitch diameter and number of teeth for the planet gear, center distance and eccentricity of the driving pin, using the value of R established in 4:

$$r = \frac{1}{8}R = \frac{1}{8}3.75 = 0.4688 \text{ in.}$$

Hence, the planet gear has a pitch diameter of 0.9375 in. and 15 teeth, and the center distance and eccentricity are

$$C = \frac{10\sqrt{2}}{9}R = \frac{10\sqrt{2}}{9}3.75 = 5.8916 \text{ in.}$$

$$r_1 = \frac{1}{72}R = \frac{1}{72}3.75 = 0.0521 \text{ in.}$$

6. Summarize design values:

$\alpha_{max} = 45$ deg.
Sun gear: Pitch diameter = 7.5 in., 120 teeth, 16 pitch.
Planet gear: Pitch diameter = 0.9375 in., 15 teeth, 16 pitch.
Center distance = 5.8916 in.
Eccentricity of driving pin = 0.0521 in.

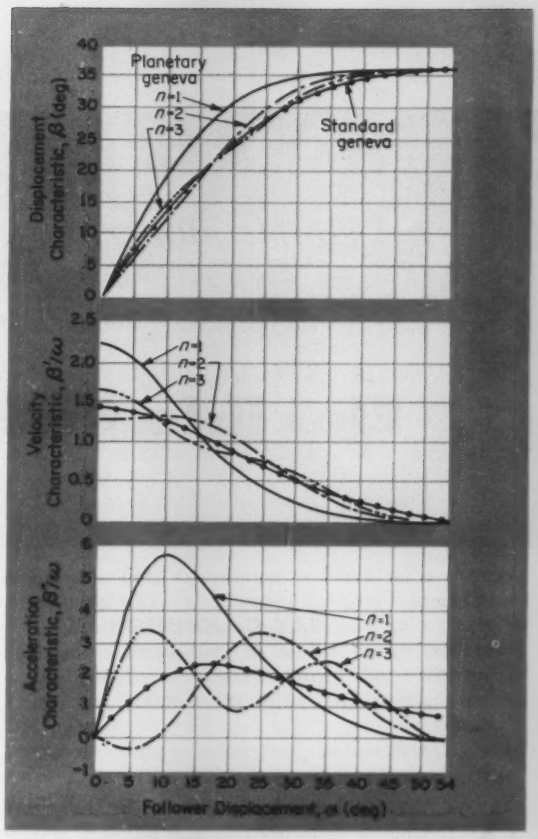


Fig. 3—Characteristics of five-slot Geneva drive.

in the beginning and higher in the end of the half engagement.

Although the shock at the start of the engagement, $\beta''' = \infty$, is eliminated in the planetary drives, some of these drives do not offer much advantage over the standard drive since both the acceleration and the rate of change of acceleration are increased. Acceleration characteristics show that planetary drives with $n = 1$ give much higher β'' and β''' in parts of the engagement cycle than the standard drive. Thus, in the case of a three-slot planetary drive with one rotation of the planet in each engagement, the maximum acceleration of the follower is nearly three times the maximum acceleration of the three-slot standard drive.

Acceleration characteristics of the five and six-slot drives show that with two rotations of the planet in each engagement, the acceleration of the follower changes from positive to negative twice in each engagement. The pin will knock against the sides of the slot, within the limits of tolerance, three times in each engagement instead of once as in the other drives, assuming that the driven system is critically damped.

Based on this analysis, the drives that give the smoothest operation (low values of β'' and β''') are the three and four-slot planetary drives with $n = 2$ and the five and six-slot drives with $n = 2$ or $n = 3$.

A simple numerical method for dynamic analysis and design of

Flexible Cam Mechanisms

RAY C. JOHNSON
Dept. of Mechanical Engineering
Yale University
New Haven, Conn.

A CAM mechanism is said to be relatively flexible if deflections in the follower system during operation are appreciable in magnitude. This condition may occur when a follower system which is statically rigid and light in weight operates at high speed—or when large-mass follower systems operate at fairly slow speeds.

This article presents a simplified numerical procedure for design and analysis of relatively flexible systems with one degree of freedom. Techniques outlined here represent an extension of the method of finite differences to dynamic cam operation.

Basic Problems: All mechanisms possess certain inherent physical properties which can cause adverse dynamic behavior. For instance, they all contain elastic regions or members which are capable of storing potential energy upon deflection. Also, they all have mass which is either lumped in a relatively well-defined region, or distributed throughout elastic regions. In either instance, the mass is capable of storing kinetic energy by virtue of its velocity. For many relatively flexible cam mechanisms, a rapid exchange of energy takes place between the elastic regions and the masses during operation, manifesting itself in the form of undesirable vibrational components on the resultant follower motion. Actual follower motion often may be appreciably different from the motion which the cam surface would impart to a perfectly rigid follower system.

Actual motion of the follower body is a function of three basic factors:

1. Characteristics of the Driving Motion from the Cam. This driving motion is sometimes referred to as the forcing function. For most cam mechanisms, this forcing function will be periodic. Hence, it can be thought of as consisting of multiple-frequency Fourier components.

2. Mechanical Properties of the Follower System. Properties of primary concern are distribu-

Nomenclature

a = Acceleration of follower, in. per sec^2 (translation) or rad per sec^2 (rotation)
b = Constant exponent which helps to define a nonlinear elastic region
C = Constant which helps to define a nonlinear elastic region
f_n = Natural frequency of follower system, cps
F = Force, lb
k = Spring constant for a linear elastic region, lb per in.
m = Mass, lb-sec^2 per in.
s = Follower displacement which is machined into the cam surface, in. (translation) or rad (rotation)
v = Velocity, in. per sec (translation) or rad per sec (rotation)
x = Actual follower displacement under dynamic operation of cam mechanism, in. (translation) or rad (rotation)
$\Delta\theta$ = Cam angle interval of displacements, deg
θ_n = Angle through which cam rotates during one complete cycle of free vibration of follower system, deg.
ω = Constant angular velocity of cam, rpm

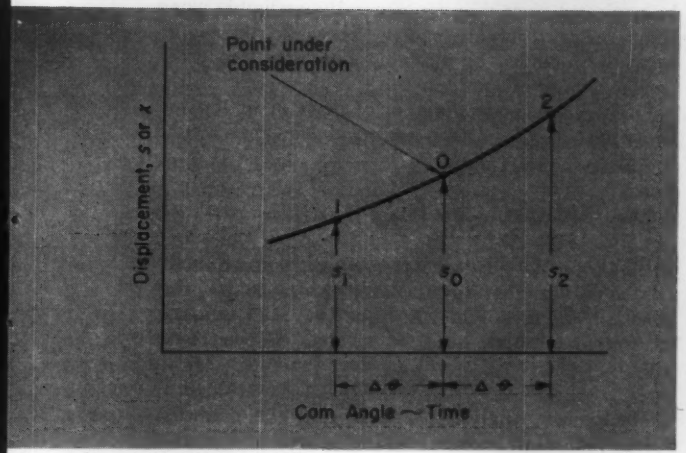


Fig. 1—Typical time-displacement relationships for the finite-differences method of cam design.

tion of mass and distribution of elastic flexibilities throughout the follower system. As a basis for evaluating these properties, the natural frequencies for free vibration of the follower system are an excellent index, serving as a measure of a system's ability to respond to a given cam command.

3. Other External Forces Acting on the Follower System. Viscous drag and the force exerted by a load spring are typical examples of external forces encountered in practice.

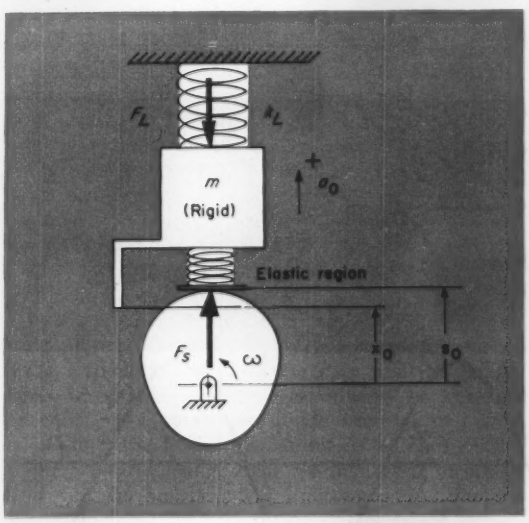


Fig. 2—Cam mechanism with a follower having single degree of freedom. Elastic deformation of the contact region during operation produces an actual displacement of the follower that is different from that machined into the cam.

Method of Finite Differences: Up to this time, the method of finite differences has been applied to cam design from only a kinematic view.[1-4] For rigid follower systems a purely kinematic attack is often adequate in design.

Assume that incremental displacements s of a particular cam motion are given at equal time intervals which correspond to equal cam-angle increments $\Delta\theta$. This assumption is based on a constant angular velocity for the cam—the usual case in practice. Displacement-time relationships may then be depicted as shown in Fig. 1. Let the general point under consideration be denoted by subscript 0. Then, displacement, velocity, and acceleration of this point are s_0, v_0, and a_0, respectively. Similarly let the preceding adjacent point be designated by subscript 1, and the following adjacent point by subscript 2.

If the conventional step milling and finishing procedure is used for the master cam, it is very likely that the primary component of the displacements, and their first and second derivatives, for the manufactured final cam will vary smoothly from point to point. For a perfectly rigid follower system, then, velocity and acceleration of the point under consideration are approximated quite accurately by (see Nomenclature)

$$v_0 = 3\left(\frac{\omega}{\Delta\theta}\right)(s_2 - s_1) \qquad (1)$$

$$a_0 = 36\left(\frac{\omega}{\Delta\theta}\right)^2(s_1 + s_2 - 2s_0) \qquad (2)$$

The term, $s_2 - s_1$, in Equation 1 is called the velocity factor, and the term, $s_1 + s_2 - 2s_0$, in Equation 2 is called the acceleration factor.

Equations 1 and 2 are extremely useful for motion analysis and development since velocity and acceleration are directly related to displacement in a simple manner.

Dynamic Analysis: A typical cam mechanism having a follower with a single degree of freedom is shown in Fig. 2. Assume that the s values represent the follower displacements which would exist if elastic deflections were not present. These are the displacements which are machined into the cam. However, under dynamic operation the contact region will deform due to the cam-contact force acting on the elastic region of contact, Fig. 2. This con-

[1]References are tabulated at end of article.

tact-region deformation produces an actual displacement, x_0, of follower body m instead of s_0.

For zero force in the follower system, the elastic region of contact is not deflected and $x_0 = s_0$. The upward direction is assumed here to be positive for deflections, velocities, and accelerations.

The general complex type of contact region which can be assumed to exist in such systems is approximated by

$$F_s = C(s_0 - x_0)^b \quad (3)$$

where F_s is the force in the elastic region near the cam surface, C and b are constants for the particular complex contact region under consideration, and s_0 and x_0, respectively, are the cam and follower displacements at the instant under consideration.

The general force-deflection relationship defined by Equation 3 can often be used with good accuracy when curved surfaces in contact (such as balls in ball bearings against their races) are combined with a linear elastic-contact region of which there are countless examples. A more complete discussion of Equation 3 and its application is given in a previous article.[5]

For the special condition where a linear force versus deflection relationship defines the elastic region of contact, Equation 3 reduces to

$$F_s = k_s(s_0 - x_0) \quad (4)$$

where k_s is the spring constant for the elastic region near the cam surface.

Velocity and acceleration relationships for body m, Fig. 2, are given by direct extension of Equations 1 and 2, replacing cam displacements s by the corresponding x values. Hence,

$$v_0 = 3\left(\frac{\omega}{\Delta\theta}\right)(x_2 - x_1) \quad (5)$$

$$a_0 = 36\left(\frac{\omega}{\Delta\theta}\right)^2(x_1 + x_2 - 2x_0) \quad (6)$$

Now that the finite-difference equations are available, Newton's second law can be applied to the mass, Fig. 2. In this analysis, damping forces will be neglected since they are generally negligible when compared with the other forces. However, they could easily be included by applying Equation 1 to problems involving viscous damping.

From a free body diagram of mass m in the follower system, Fig. 2, application of Newton's second law gives

$$C(s_0 - x_0)^b - F_L = 36m\left(\frac{\omega}{\Delta\theta}\right)^2(x_1 + x_2 - 2x_0) \quad (7)$$

In Equation 7, F_L is calculated by well-known methods as a function of displacement x_0 and spring constant k_L (see Fig. 2). Equation 7 is uniquely easy to manipulate since it involves displacements only.

Mechanism Analysis: Suppose that the manufactured cam displacement values, s, are known and response x of the follower mass, Fig. 2, must be found. Solving Equation 7,

$$x_2 = \frac{C(s_0 - x_0)^b - F_L}{36m\left(\frac{\omega}{\Delta\theta}\right)^2} + (2x_0 - x_1) \quad (8)$$

For the special case in which a linear type of elastic region is near the cam surface, as defined by Equation 4, two conditions must be examined. When load-spring force $F_L = 0$, Equation 8 reduces to

$$x_2 = \frac{k_s(s_0 - x_0)}{36m\left(\frac{\omega}{\Delta\theta}\right)^2} + (2x_0 - x_1) \quad (9)$$

When a load spring force, F_L, is present, Equation 8 becomes

$$x_2 = \frac{k_s(s_0 - x_0) - F_L}{36m\left(\frac{\omega}{\Delta\theta}\right)^2} + (2x_0 - x_1) \quad (10)$$

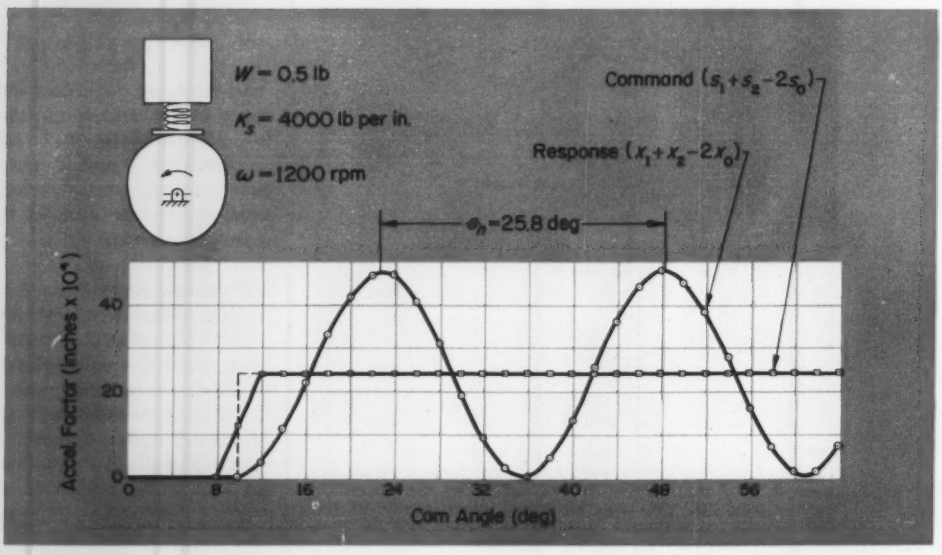


Fig. 3 — Command-response acceleration curves for a cam-driven rigid body mass having a linear elastic-contact region (Equation 4).

Equations 8, 9, or 10 can be applied in a sequential manner directly to analysis problems. However, this approach requires that analysis start at a dwell point, or any other region where the displacements x_0 and x_1 of the follower mass are known for two adjacent points. Displacement x_2 can then be calculated from Equation 8, 9, or 10. With this point established, the follower mass displacement for the next point can be determined in a similar manner. Thus, follower response can be determined in a straightforward sequential manner. This general method of analysis is illustrated later in the Design Example.

Although application of the sequential calculation procedure should present no difficulties, particularly where a desk calculating machine is employed and results are tabulated, there are certain limitations to the accuracy possible in response calculations. These limitations will be considered later.

Cam Design: Cam command values s necessary to produce a desired follower body response x can be evaluated by an approach similar to that used previously.

Solving for s_0 in Equation 7,

$$s_0 = \left[\frac{F_L + 36m \left(\frac{\omega}{\Delta\theta} \right)^2 (x_1 + x_2 - 2x_0)}{C} \right]^{1/b} + x_0 \quad \ldots\ldots (11)$$

For the special case where a linear type of elastic region is near the cam surface, two conditions must again be considered. When $F_L = 0$,

$$s_0 = \frac{36m \left(\frac{\omega}{\Delta\theta} \right)^2 (x_1 + x_2 - 2x_0)}{k_s} + x_0 \qquad (12)$$

When force F_L is present,

$$s_0 = \frac{F_L + 36m \left(\frac{\omega}{\Delta\theta} \right)^2 (x_1 + x_2 - 2x_0)}{k_s} + x_0 \qquad (13)$$

Depending on the particular design problem, Equation 11, 12, or 13 can be applied directly to determine the necessary cam displacement s_0 at each point since it is assumed that all of the desired follower mass displacements x are initially known. For Equations 11 and 13, load-spring force F_L can easily be calculated for each point as a simple linear function of the desired follower displacement x_0.

Practical Limitations: From a purely mathematical standpoint there are no limitations on the use of finite differences for dynamic cam analysis or design. Acceptable accuracy can always be obtained by choosing a small cam-angle interval and then calculating the initial displacements to enough significant figures using exact mathematical formulas. However, certain practical limitations are imposed by unavoidable manufacturing errors which generally limit the accuracy of specification for cam displacements to the nearest 0.0001 in. These limitations are generally only significant for relatively rigid follower systems.

As previously stated, derivation of acceleration Equations 2 and 6 is based on smoothly varying displacements, velocities, and accelerations between any three adjacent points. This assumption must be satisfied to obtain accurate results with response Equations 8, 9, and 10. For many follower body total motions, an oscillatory component having appreciable acceleration amplitude, will exist at the natural frequency of the follower system. This natural frequency is[6]

$$f_n = \frac{1}{2\pi} \left(\frac{k_L + k_s}{m} \right)^{1/2} \qquad (14)$$

where k_L is the force gradient for the follower load spring, k_s is the force gradient for the elastic region near the cam surface, and m is the mass of the lumped follower body.

Thus, for accurate results with Equation 8, 9, or 10, the cam-angle interval should be relatively small in relation to the vibratory component of follower motion.

Results of a typical follower-response analysis using Equation 9 are plotted in Fig. 3. Here, a constant-acceleration command results in an oscillatory follower response at the natural frequency of the follower system. One cycle of oscillatory motion at the natural frequency will occur during a cam angle rotation, θ_n, which can be determined from

$$\theta_n = \frac{6\omega}{f_n} \qquad (15)$$

For the follower system analyzed in Fig. 3, the natural frequency determined from Equation 12 is $f_n = 279$ cps. From Equation 15, $\theta_n = 25.8$ degrees per cycle of free vibration. Follower-body response was plotted directly from Equation 9.

Notice that the vibratory component of motion occurs at the correct natural frequency, and that the amplitude of total acceleration is exactly twice that of the constant-acceleration cam command. These results are in agreement with the findings of others[7] and confirm the accuracy of Equations 8, 9, and 10 for response analysis. For this analysis, Fig. 3, the cam angle interval, $\Delta\theta = 2$ degrees, is relatively small when compared with the natural frequency angle, $\theta_n = 25.8$ degrees. Hence, good accuracy should be expected and was obtained.

In the selection of cam-angle interval $\Delta\theta$, a generally satisfactory criterion for most problems is

$$\Delta\theta < \frac{\theta_n}{2\pi} \qquad (16)$$

Equation 16 provides a basis for evaluating the size of cam angle interval needed for accurate application of response Equations 8, 9, and 10. It is assumed, of course, that this angle is small when compared with the variation of the resultant follower mass motion. If it is not small enough, use of Equations 8, 9, and 10 will give an unsmooth acceleration variation for the follower mass.

The requirement defined by Equation 16 imposes a practical limitation on follower response calculations for manufacturable cam mechanisms with relatively rigid follower systems. As natural frequency

f_n increases, $\Delta\theta$ must be decreased. A point will be reached where the cam displacement values are unobtainable due to machining limitations. Then, the resultant follower accelerations will be influenced more by machining errors than by the primary component of cam motion.

This limitation also applies to Equations 11, 12, and 13 in the design of relatively rigid follower systems. However, for relatively flexible cam mechanisms, the methods presented here provide accurate design control of both accelerations and displacements of the follower mass.

Two other limitations may be of importance in design problems that involve cam dynamics. If an appreciable amount of mass exists in the elastic region near the cam surface, dynamic force and stress effects in the cam contact region will have to be considered. It may be necessary to choose a follower body motion having a continuous third and fourth derivative in original design work. However, for many high-speed cam design problems, the appreciable elastic region will be at the immediate cam contact region, and the mass here will always be negligible. In such cases, motion of the main follower body will be of primary importance.

For follower systems which are very flexible, the problem of undercutting the cam surface in manufacture can also be important. Whether or not undercutting will exist can be determined either analytically or graphically. The analytical method is beyond the scope of this article; however, the graphical method involves making an accurate large scale layout of cam-follower geometric relationships.

The undercutting difficulty can often be eliminated by making either one or both of the following changes: 1. Alter the geometry of the follower mechanism. 2. Modify the desired follower response to make the variation of required cam displacements less severe.

Analysis Example: Determine the follower response for a cam mechanism in which the cam-command motion is of the dwell-rise-dwell constant-acceleration type with a total throw of 0.2400 in. in 40 degrees of cam rotation. Cam displacement values s are given in Table 1. These displacements were calculated by exact mathematical methods. The cam acceleration factors, $s_1 + s_2 - 2s_0$, were calculated directly from these values.

Equation 9 will be used for follower-response calculations. A linear elastic region near the cam surface is assumed. A load spring is not employed. Force gradient for the linear contact region is k_s = 4000 lb per in. Follower lumped weight is 0.5 lb or m = 0.500/386 lb-sec² per in. Constant cam angular velocity, ω = 1200 rpm. Cam angle interval $\Delta\theta$ = 2 degrees.

For this design problem, Equation 9 becomes

$$x_2 = (0.238)(s_0 - x_0) + (2x_0 - x_1) \qquad (17)$$

Since all of the s values are given, the x_2 values can be calculated in succession by direct application of this equation, providing that x_0 and x_1 are known for each particular calculation.

In Table 1, the x values will be identical to the s values at least up to the 10-degree point. The cam obviously does not move the follower during the 0 to 10-degree dwell period, assuming that the follower is initially at rest during that period. Hence,

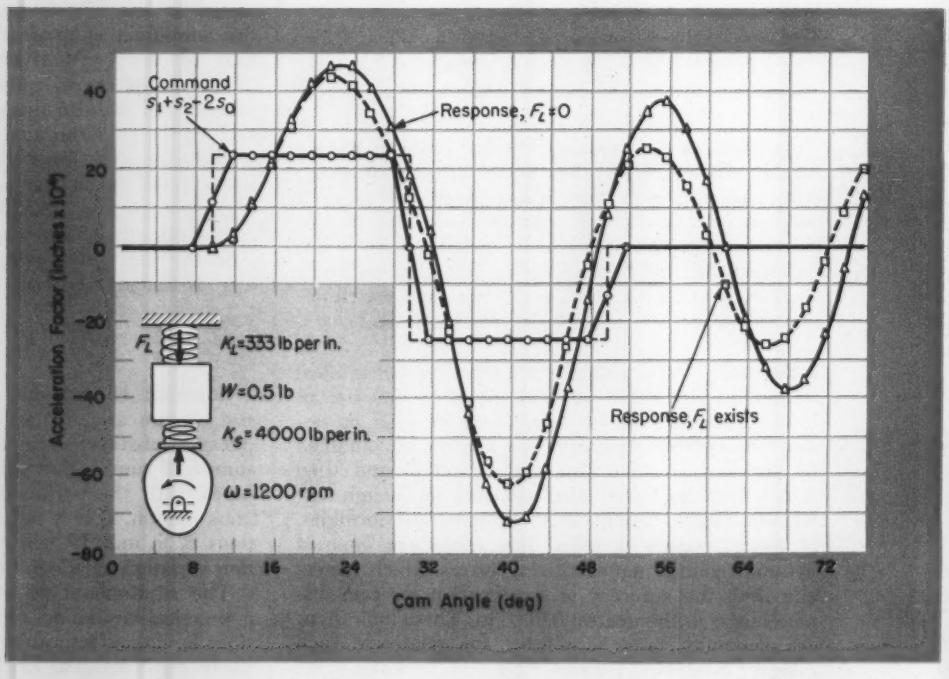


Fig. 4 — Command-response acceleration curves for cam mechanism analyzed in design example. Dashed response curve shows effect of adding a cam-load spring to the system.

the x values are all known up to the 10-degree point.

The 12-degree point will be considered as the first unknown x_2 value. For the first calculation then, the 12-degree point will be identified with the subscript 2, the 10-degree point will be identified with the subscript 0, and the 8-degree point will be identified with the subscript 1. Therefore, for the first calculation, $s_0 = 1.0000$, $x_0 = 1.0000$, and $x_1 = 1.0000$. From Equation 17, $x_2 = 1.0000$ in.

Next, consider the 14-degree point as the x_2 value to be determined. For this calculation x_0 corresponds to the 12-degree point and x_1 to the 10-degree point. Here, $s_0 = 1.0012$, $x_0 = 1.0000$, and $x_1 = 1.0000$. From Equation 17, $x_2 = 1.0003$ in.

This process is repeated down through the 78-degree point, giving results tabulated in Table 1. From the calculated x values, follower-response acceleration factors, $x_1 + x_2 - 2x_0$, are calculated. These values are plotted in Fig. 4.

Fig. 4 also shows the results which were obtained for exactly the same problem as in Table 1, except a load spring was assumed to act on the mass. This load spring has a force gradient of 333 lb per in. and exerts a downward force of 80 lb during the initial dwell from 0 to 10 degrees. This 80 lb force causes a contact region deflection of 80/4000 = 0.0200 in. Therefore, during the initial dwell period, $s_0 = 1.0000$ as before, but $x_0 = x_1 = 1.0000 - 0.0200 = 0.9800$ in., since the s and x values are only identical under the existence of zero force on the follower body, as previously discussed. For these follower-response calculations, Equation 10 was used in the same manner as Equation 9 had been. After the follower mass starts moving, it is easy to calculate F_L by commonly known methods, since F_L is linearly related to x_0, which is known for each calculation, by the load spring force gradient k_L.

From the calculated follower-response x values, the acceleration factors were calculated directly to find the other response curve shown in Fig. 4.

Table 1—Calculations for Design Example

θ (deg)	s (in)	x (in)	(s_0-x_0)	$0.238\times(s_0-x_0)$	$(2x_0-x_1)$	$(x_1+x_2-2x_0)$
0	1.0000	1.0000				.0000
2	1.0000	1.0000				.0000
4	1.0000	1.0000				.0000
6	1.0000	1.0000				.0000
8	1.0000	1.0000				.0000
10	1.0000	1.0000	.0000	.0000	1.0000	.0000
12	1.0012	1.0000	.0012	.0003	1.0000	+.0003
14	1.0045	1.0003	.0045	.0011	1.0006	+.0011
16	1.0106	1.0017	.0091	.0022	1.0031	+.0022
18	1.0192	1.0053	.0139	.0033	1.0089	+.0033
20	1.0300	1.0122	.0178	.0042	1.0191	+.0042
22	1.0432	1.0233	.0199	.0047	1.0344	+.0047
24	1.0588	1.0391	.0197	.0047	1.0549	+.0047
26	1.0768	1.0594	.0172	.0041	1.0801	+.0041
28	1.0972	1.0842	.0130	.0031	1.1088	+.0031
30	1.1200	1.1119	.0081	.0019	1.1396	+.0019
32	1.1428	1.1415	.0013	.0003	1.1711	+.0003
34	1.1632	1.1714	−.0082	−.0020	1.2013	−.0020
36	1.1812	1.1993	−.0181	−.0043	1.2272	−.0043
38	1.1968	1.2229	−.0261	−.0062	1.2485	−.0062
40	1.2100	1.2403	−.0303	−.0072	1.2577	−.0072
42	1.2208	1.2505	−.0297	−.0071	1.2607	−.0071
44	1.2292	1.2536	−.0244	−.0058	1.2567	−.0058
46	1.2352	1.2509	−.0157	−.0037	1.2482	−.0037
48	1.2388	1.2445	−.0057	−.0014	1.2381	−.0014
50	1.2400	1.2367	.0033	.0008	1.2289	+.0008
52	1.2400	1.2297	.0103	.0025	1.2227	+.0025
54	1.2400	1.2252	.0148	.0035	1.2207	+.0035
56	1.2400	1.2242	.0158	.0038	1.2232	+.0038
58	1.2400	1.2270	.0130	.0031	1.2298	+.0031
60	1.2400	1.2329	.0071	.0017	1.2388	+.0017
62	1.2400	1.2405	−.0005	−.0001	1.2481	−.0001
64	1.2400	1.2480	−.0080	−.0019	1.2555	−.0019
66	1.2400	1.2536	−.0136	−.0032	1.2592	−.0032
68	1.2400	1.2560	−.0160	−.0038	1.2584	−.0038
70	1.2400	1.2546	−.0146	−.0035	1.2532	−.0035
72	1.2400	1.2497	−.0097	−.0023	1.2448	−.0023
74	1.2400	1.2425	−.0025	−.0006	1.2353	−.0006
76	1.2400	1.2347	.0053	.0013	1.2289	+.0013
78	1.2400	1.2282				

References

Cited references to Machine Design articles by the author are:

1. "Cam Design," Vol. 27, No. 11, November, 1955, pp. 195-204.
2. "Cam Profiles," Vol. 28, No. 25, December 13, 1956, pp. 129-132.
3. "Cam Dynamics," Vol. 29, No. 3, February 7, 1957, pp. 105-108.
4. "Cam Design—Accuracy, Applications," Vol. 29, No. 23, November 14, 1957, pp. 159-161.
5. "Impact Forces in Mechanisms," Vol. 30, No. 12, June 12, 1958, pp. 138-146. (Also, *Transactions of the Fourth Conference on Mechanisms*, Penton Publishing Co., Cleveland, 1958, pp. 16-24.)

Other references are:

6. J. P. Den Hartog—*Mechanical Vibrations*, McGraw-Hill Book Co. Inc., New York, 1947.
7. C. N. Neklutin—"Vibration Analysis of Cams," Machine Design, Vol. 26, No. 12, December, 1954, pp. 190-198. (Also, *Transactions of the Second Conference on Mechanisms*, Penton Publishing Co., Cleveland, 1954, pp. 6-14.)

Acknowledgement

This article is based on a paper presented at the Fifth Conference on Mechanisms, cosponsored by Purdue University and Machine Design, October 13-14, 1958.

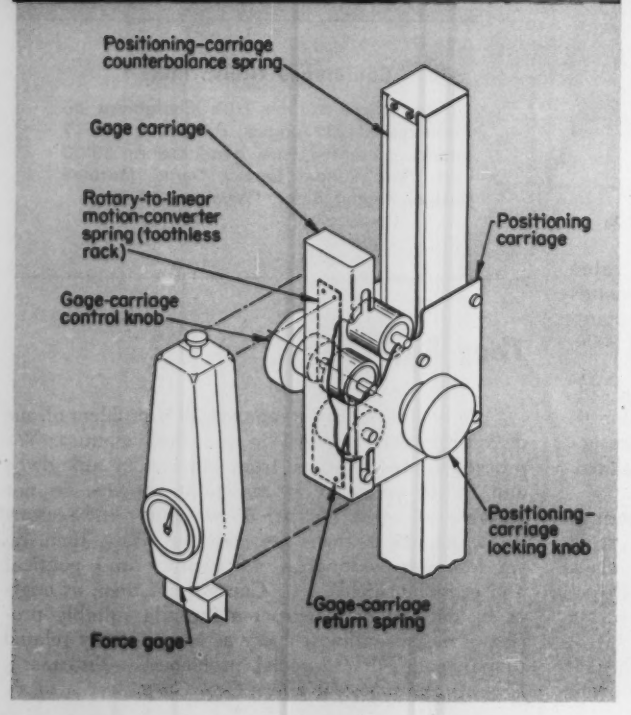
Conference Transactions

Transactions of the Fifth Conference on Mechanisms (239 pages), containing the 19 papers presented, are available at $3.00 each from Reader Service Dept., **Machine Design**, Penton Bldg., Cleveland 13, Ohio.

They Say . . .

"We engineers, in the analysis of a problem of our own profession, proceed in a logical manner. We proceed from absolutes, from knowns to unknowns and in an endeavor to resolve unknowns, do not ignore experience. Neither do we ignore the reasons for which the knowns are constant. Why, then, do we lose our way when we venture into political and economic fields? . . . Can we not then, as engineers, develop or construct a formula suitably precise to measure almost every action presently related to our political and social problems?"—Thomas J. Bannan, *president, Western Gear Corp.*

Spring Functions as Rack and Pinion



"TOOTHLESS-RACK" SIMPLIFIES the construction and smooths the operation of a new testing instrument. Rotary motion of the instrument's gage-carriage control knob is converted into linear motion at the gage head through a prestressed coiled band of spring steel. The coil of rotary-to-linear motion-converter spring is drum-mounted on the stationary positioning carriage, and its extended end is secured to the movable gage carriage. When the control knob is turned clockwise, it winds up the extended end of the spring to pull the gage and its carriage downward, as required by the test procedure. Total linear travel of the "toothless rack" is 2 in.

The Scorebend Tester was designed to measure the force needed to open up flat, folded paperboard cartons. This force can be critical to the proper functioning of automatic carton filling lines.

The "toothless rack" is irreversible and is used only to advance the gage against the carton. It is returned to the raised position automatically, when the control knob is released, by a second constant-force extension spring which is mounted in opposition to the first.

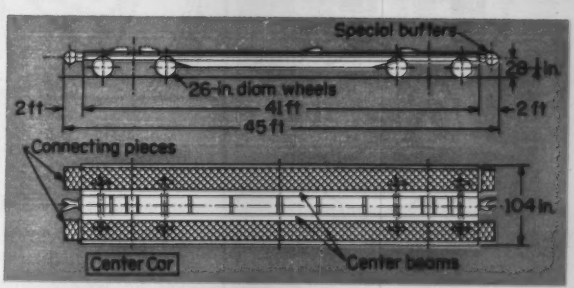
A third constant-force spring counterbalances all the moving components of the column supported tester. Its coil is mounted on the positioning carriage which is adjustable at any height on the column to accommodate cartons of various sizes. The extended end of the spring is secured near the top of the post. The positioning carriage is held in the working position by a friction lock engaged by the locking knob. When the clamping pressure is released, this third spring will slightly overbalance the positioning carriage causing the entire adjustable assembly to drift slowly to the top of the column when not being positioned by hand.

All three special springs, known as Neg'ator springs, are made by Hunter Spring Co. Div., American Machine and Metals Inc., Lansdale, Pa. The carton-testing instrument was made by the same company.

Smaller Wheels on Piggyback Flatcars Increase Permissible Loading Height

SMALL-DIAMETER WHEELS reduce height of railroad freight cars from a standard 49.5 in. to 30.5 in. above the top of the rails. The 26-in. diameter wheels permit increasing the height of the load by 19 in. Designed for piggyback trains of the French National Railroads, the car is 45 ft. long and 104 in. wide. Load capacity is 34 tons and empty weight 16 tons.

Since trucks, trailers and tractors are maneuvered into position while they are on the train, automatic couplings and special buffers are but 28¼ in. above the rails. Cars within a train's piggyback section have the low-height couplings and buffers on both ends. End cars, connecting with a locomotive or other parts of the train, have an elevated end portion carrying conventional couplings and buffers 41⅜ in. above rails.

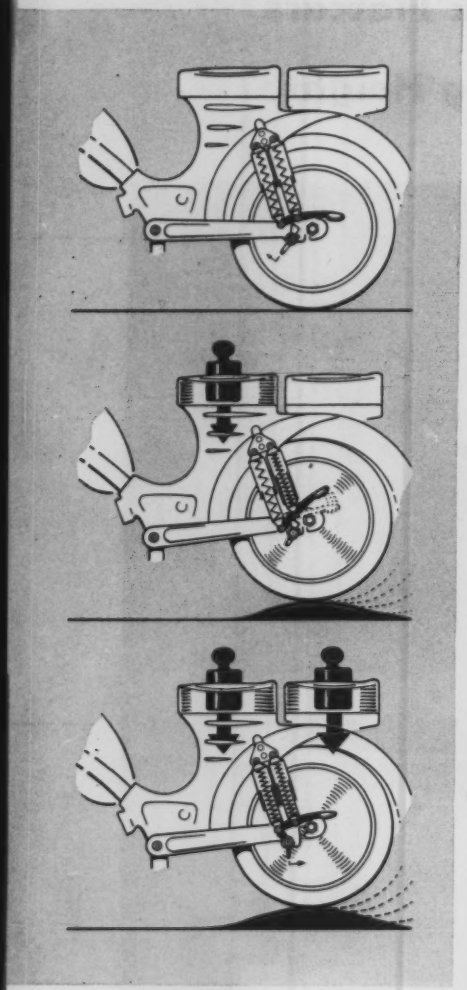


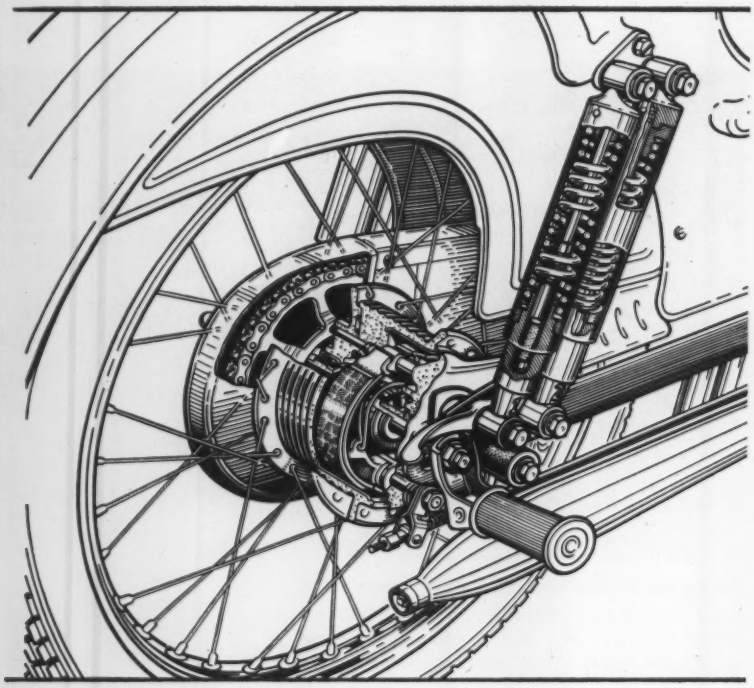
ADJUSTABLE WHEEL CHOCKS are positioned by crossbars linking center beams with rack-type holders attached to platform sides.

Vehicles are loaded and unloaded via mobile ramps and guided on platforms by center beams. Connecting pieces permit maneuvering from one car to another.

The car is a development of Compagnie Francaise de Materiel de chemin de fer et Generale de Construction, Paris, France, and Societe Nouvelle des Ateliers de Venissieux, Venissieux Rhone, France.

Rear Suspension Is Adjustable





TWIN COIL SPRINGS mounted on each side of the swinging rear fork of a German motorcycle can be adjusted for either a one or a two-passenger load. The rear coil springs on each side are pretensioned for an initial load of 90 lb; these springs take care of the basic vehicle weight, luggage, and part of rider's weight.

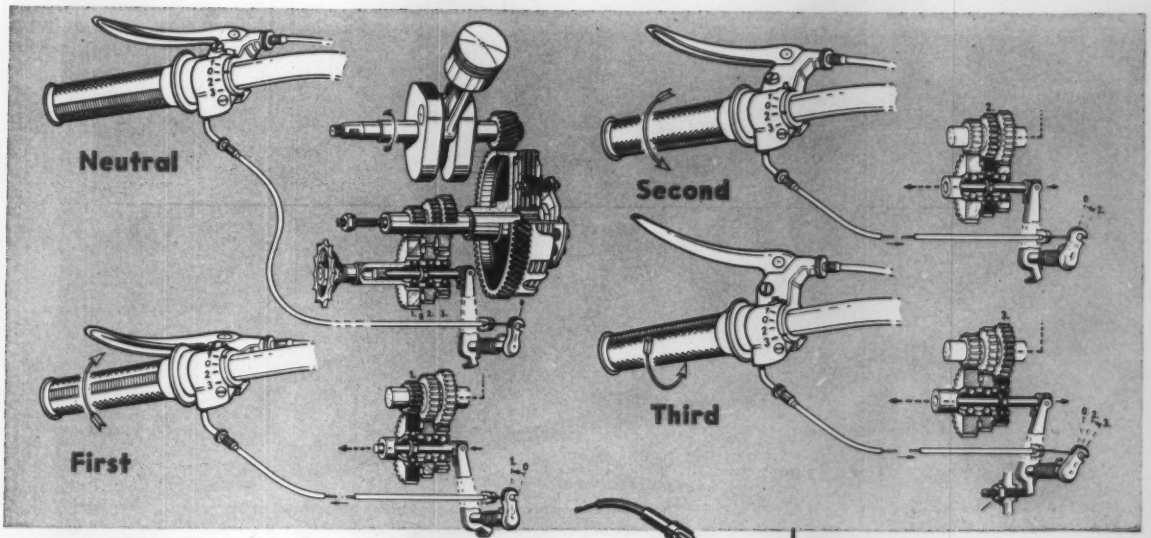
A special locking device can connect the front springs on each side of the rear fork when a second passenger is carried. When the second pair of springs is brought into operation, the suspension gives a comfortable ride with loads of more than 500 lb.

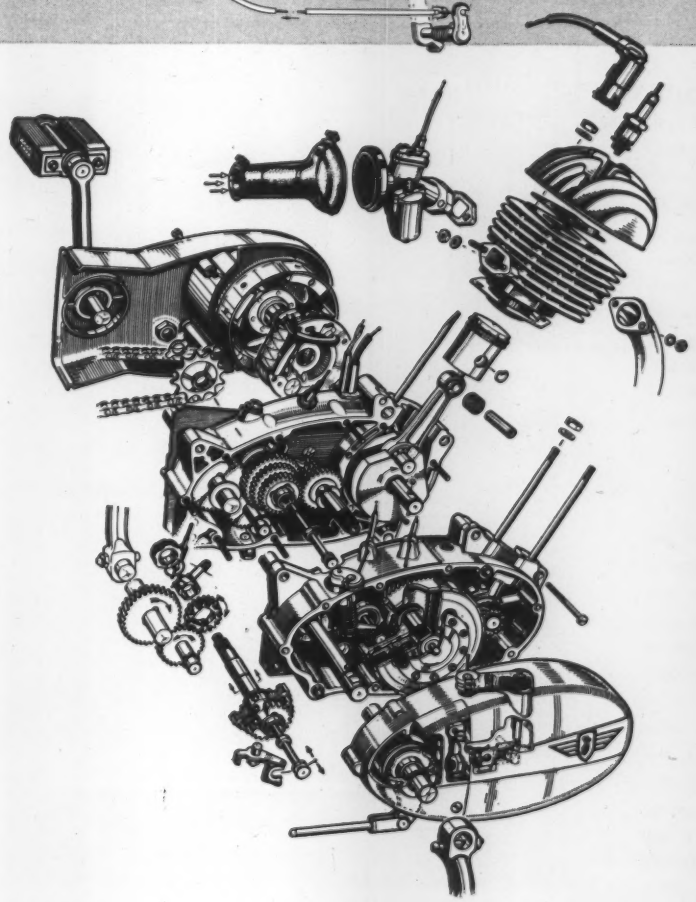
Front and rear brakes are 4 3/4 in. in diameter, with a 1 in. wide brake lining. Bike is fitted with 23 x 2.5 in. motorcycle type tires. Wheel base is 4 ft.

SMOOTH AND GRACEFUL LINES are obvious in the styling of the Zundapp Super Combinette manufactured by the Zundapp Works GmbH, Munich, West Germany.

Details of this design were reported by O.K. Grade, Springdale, Conn.

for Either One or Two Passengers



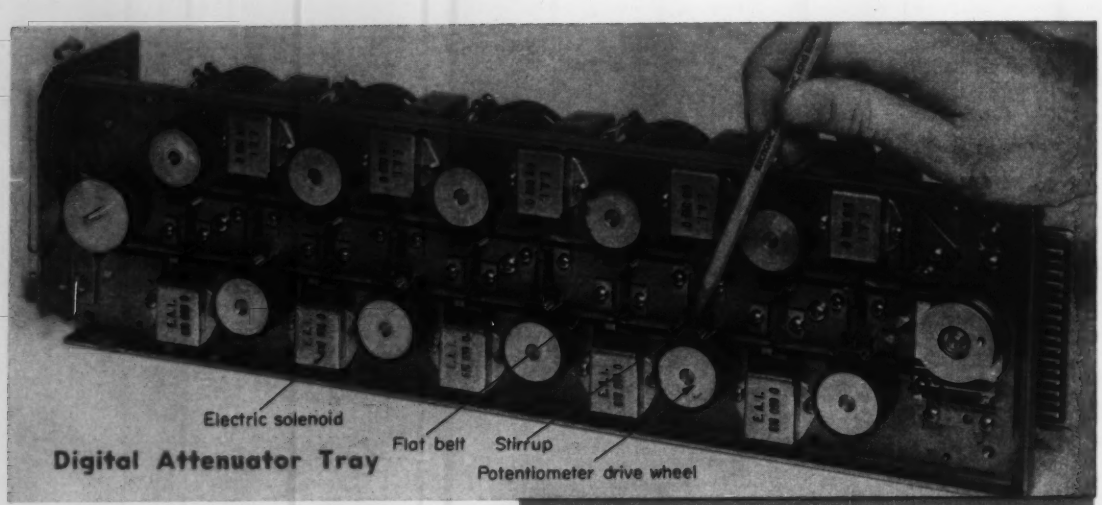


GEAR ENGAGEMENT is made with a single control cable. Neutral, or a particular gear, is selected by setting the position of the handle grip. When moved by the control cable, a collar on the selector shaft pushes four steel balls radially out to engage the output shaft and the selected gear.

HELICAL-GEAR DRIVE in the clutch assembly provides a quiet running engine and gives a favorable power-transmission ratio. A special feature of the design is the elimination of any chain-reduction gearing.

The three-plate, oilbath clutch, adjustable from the outside, is mounted behind the right-hand outer engine casing. The left outer casing encloses the lighting and ignition system, and the sprocket for the final drive to the rear wheel.

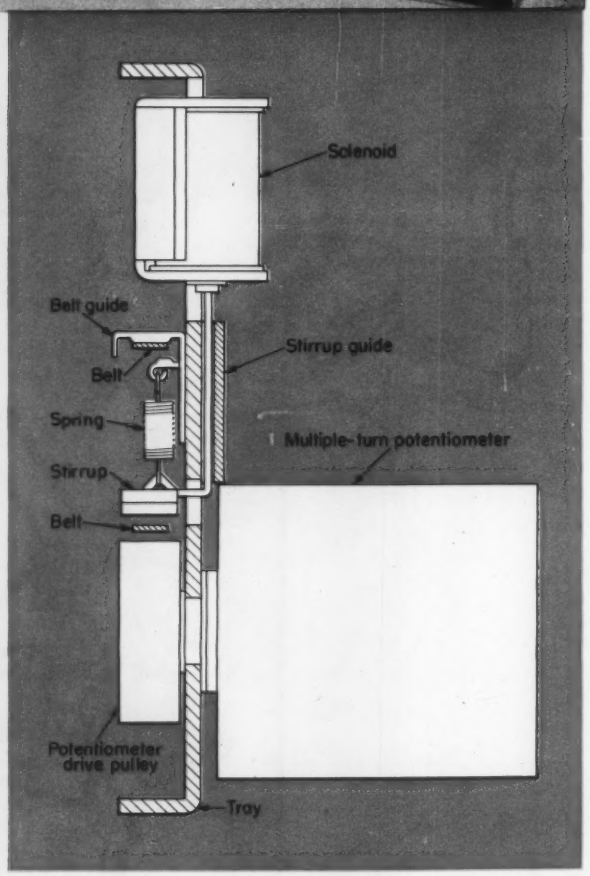
Servo Motor Driving Five Belts



Digital Attenuator Tray

SETTING ACCURACY OF 1 PART IN 10,000 is achieved in multiple-potentiometer setting system. Designed to set ten-turn coefficient potentiometers in an analog computer, the system uses a single acceleration-type servo motor to set any one of 50 potentiometers.

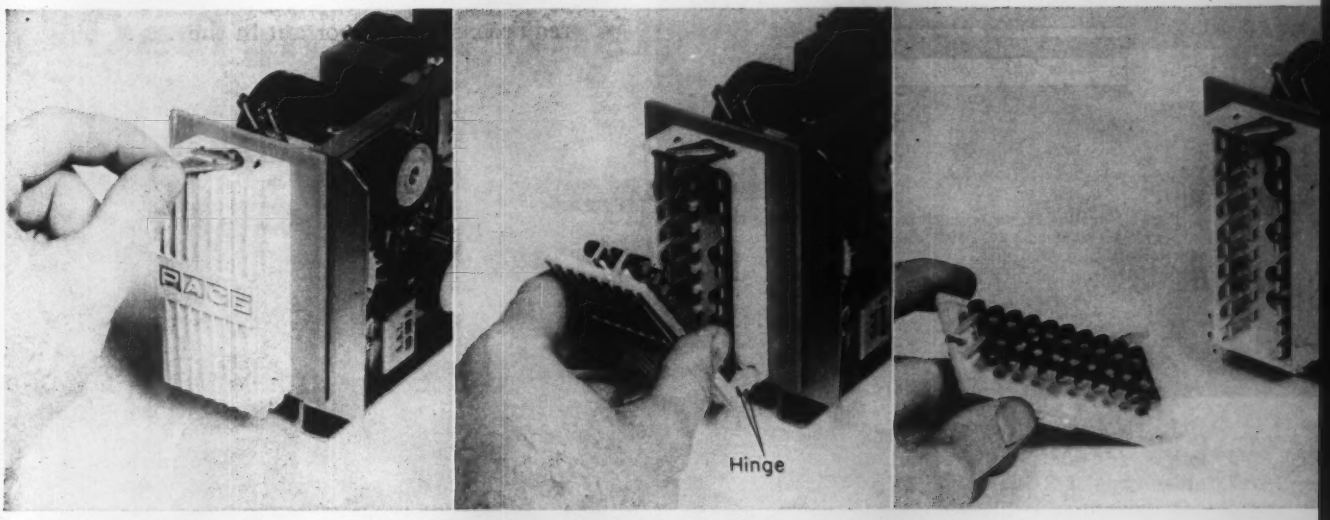
In assembly, the servo motor is bellows-coupled to five belt-drive pulleys—one in each of five digital attenuator trays in the computer. In each attenuator tray, five potentiometers are mounted above a flat-belt drive and five below. Drive wheels on the potentiometers are spaced slightly away from the flat-belt drive.

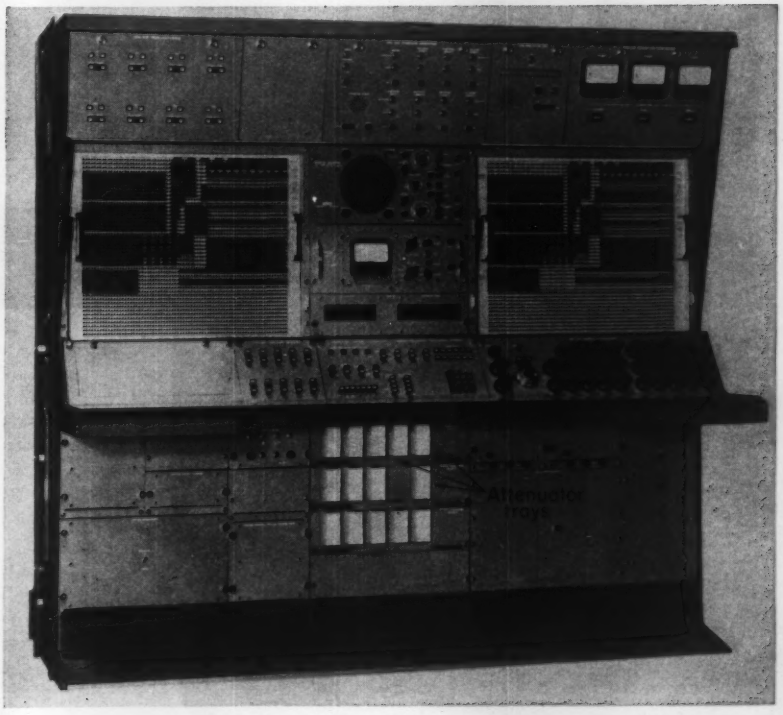


STIRRUP PUSHES BELT against preselected potentiometer drive wheel during setting operation. Although only one of the 50 pots can be set at the same time, setting time is very short. Pots are set by punched-paper tape, a key board, or from the digital attenuator control on the console.

Each stirrup is operated by an electric solenoid. When a particular pot is to be set, the stirrup brings the belt into contact with the pot drive wheel before the servo motor starts. The servo turns the pot and stops before the stirrup is released. Plug-in relays next to the pots read the actual pot setting.

Sets Any One of 50 Potentiometers





REMOVABLE FUSE HOLDER on the front of each attenuator tray is designed for both convenience and safety. Hook-shaped members at the bottom of the removable section of the fuse holder fit over metal studs to form a hinge. The hinged opening or closing action of the holder allows the fuses to break or make contact one at a time.

The design makes it easy to find and replace individual blown fuses. In fact, the complete holder can be replaced quickly to cut computer downtime.

SPECIAL-PURPOSE ANALOG COMPUTER manufactured by Electronic Associates Inc., Long Branch, N. J. The servo pot-setting system used in the computer was designed by mechanical engineer, Walter Zober. The designer of the fuse holder was Harry Williamson, mechanical engineer.

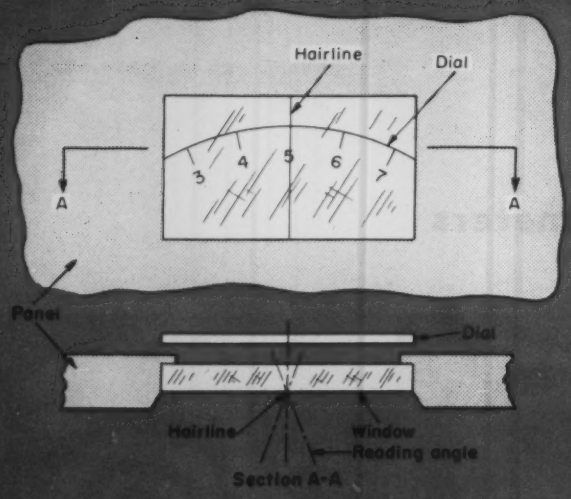


Fig. 1—Reading error is increased by off-center viewing and excessive distance between hairline and dial.

Dials, scales, and pointers need protection. They must also be clearly visible. Combining these two requirements is important in the . . .

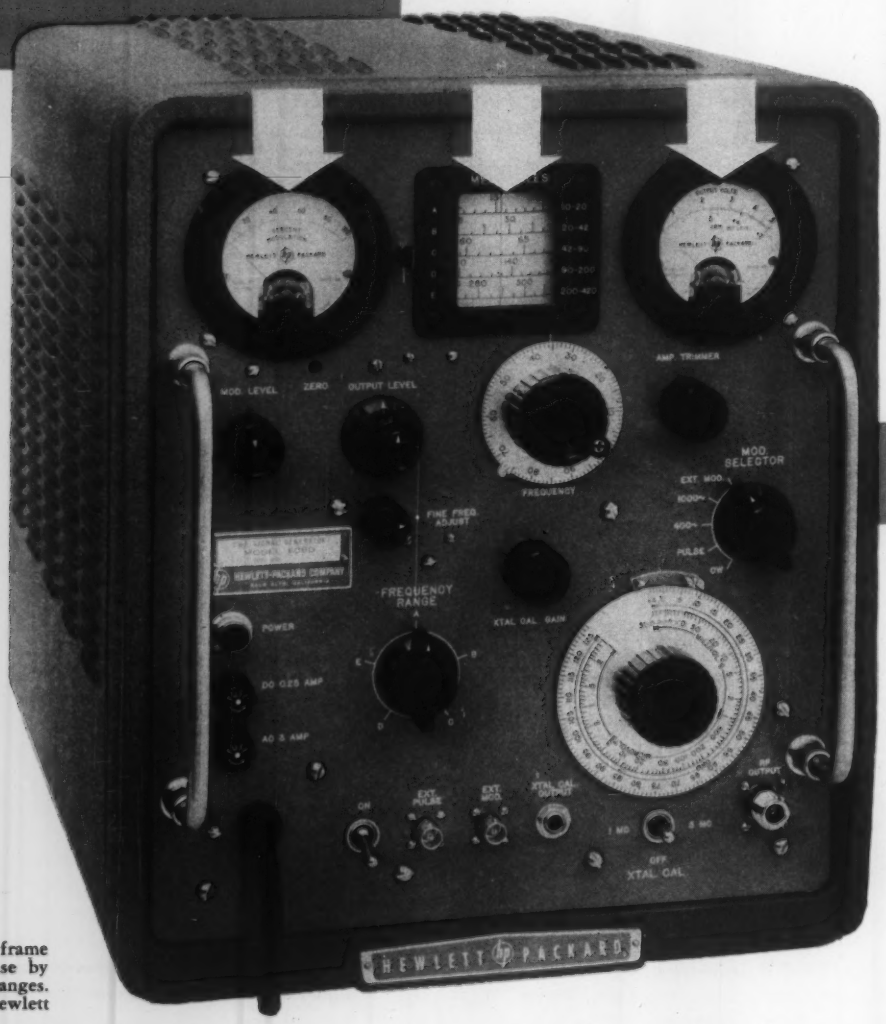


Fig. 2 — Window frame serves additional use by identifying scale ranges. (Photo, courtesy Hewlett Packard Co.)

Design of Panel Windows

FRANK WILLIAM WOOD JR.
Engineer, Systems Development Dept.
Vitro Laboratories
Silver Spring, Md.

MECHANICAL damage to delicate indicators, meter movements, and scales can be prevented by panel windows made of plastic, plain glass, or safety glass. With proper sealing, windows can also protect against dust, gas, water, and explosive atmospheres. A clear, unobstructed view of the specific section of dial or scale that must be read is also a necessity. The window should not fog, attract dust, or be unusually susceptible to scratches.

Size of the window opening should permit easy viewing of the dial. Maximum reading angle is determined by:

1. Distance at which the dial must be read.
2. Relative position of the person reading the dial.
3. Human visual angle limitations.

Military specification MIL-E-5400 states that a dial shall be readable at a distance of 2 ft and within an angle of 30 degrees from a line through the dial center and perpendicular to the panel.

In cases where an indicating line is scribed on the window, reading errors caused by parallax, Fig. 1, can be minimized by scribing the hairline on the dial side and locating the window as close as possible to the dial. Thick windows can have hairlines scribed on both sides to indicate when the scale

Fig. 3 — Triangular window is used for disc dial having scales on different radii. (Photo, courtesy Hewlett Packard Co.)

Design of Panel Windows

is being viewed directly. Another aid when the observer can move into position is a mirror placed behind the dial or used as the dial background.

A frame for a panel window produces the same effect on the viewer as the frame for a picture—it provides a boundary for the eyes and sets the window apart from surrounding objects such as knobs, levers, etc. A frame should be prominent enough for quick spotting, yet not be so gaudy as to be distracting. Frames may vary from simple engraved openings to elaborate three-dimensional molded designs. A double purpose is served by the frame in Fig. 2.

Final window shapes may be determined by:

1. Fabrication economy.
2. Styling of unit.
3. Percentage of dial viewed.
4. Panel space limitations.

Shapes may be rectangular, square, oval, or round. A triangular window is shown in Fig. 3, and Fig. 4 illustrates a special shape that accentuates the reading portion of the dial. Larger windows, Fig. 5, are sometimes used to show several scales simultaneously for comparison or for coarse and fine reading.

Methods of providing windows and attaching them to panels are shown in Fig. 6. When environment protection is required, windows must be sealed in place. In addition to Fig. 6c and *f*, other sealing and mounting styles are illustrated in Fig. 7.

Military specifications concerned with window design and application are listed in Table 1.

Table 1—Military Specification References

Item	Subject	Specification
Plastic sheet	Material	MIL-P-80B MIL-E-16400A, par. 3.5.1.5.5 MIL-E-19100, par. 3.5.15.5
Glass	Material	MIL-E-19100, par. 3.5.10 MIL-E-16400A, par. 3.5.10
Clips	Fastening to panel	MIL-E-19100, par. 3.12.11 MIL-E-16400A, par. 3.12.11
Gaskets	Sealing	MIL-E-16400A, par. 3.3.21.2 MIL-E-19100, par 3.3.20.2
Angle of visibility	Size of opening	MIL-E-5400, par. 3.1.6.2

Notes: MIL-E-19100 is general specification for naval shipboard electronic training equipment. MIL-E-16400A is general specification for naval ship and shore electronic equipment. MIL-E-5400 is general specification for airborne electronic equipment.

Fig. 4—Special window shape emphasizes reading area. (Photo, courtesy Donner Scientific Co.)

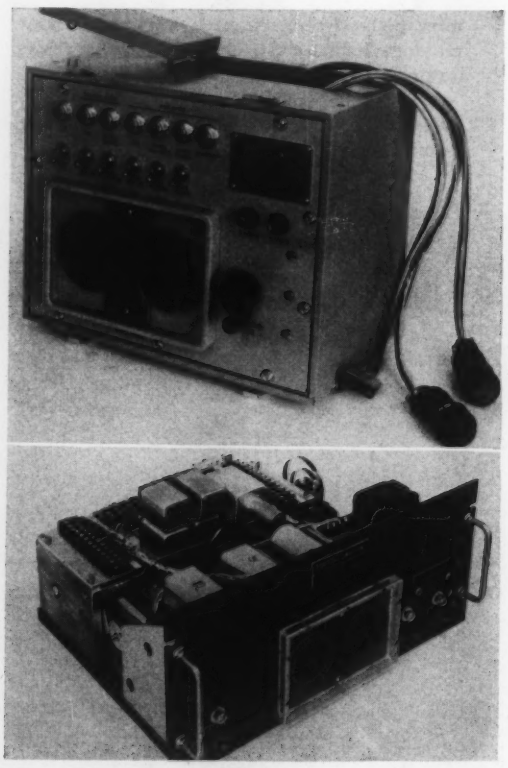


Fig. 5—Rectangular windows for external dials were designed by Vitro Laboratories with both framed glass and all-acrylic enclosures.

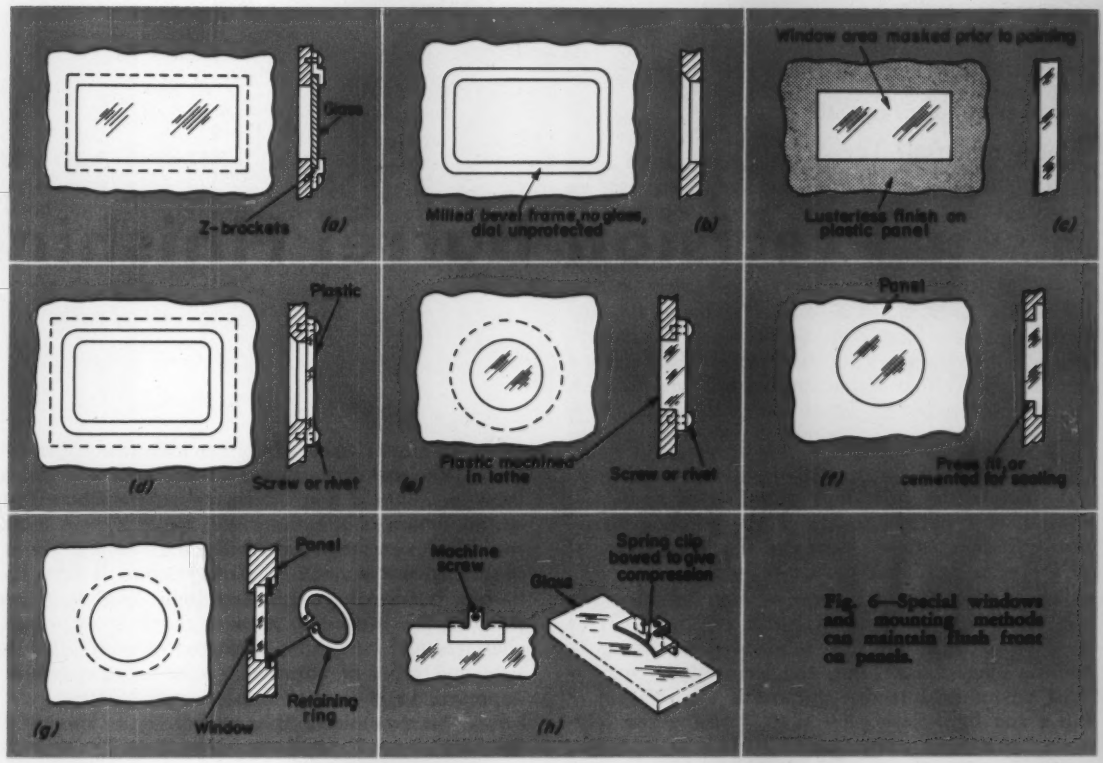


Fig. 6—Special windows and mounting methods can maintain flush front on panels.

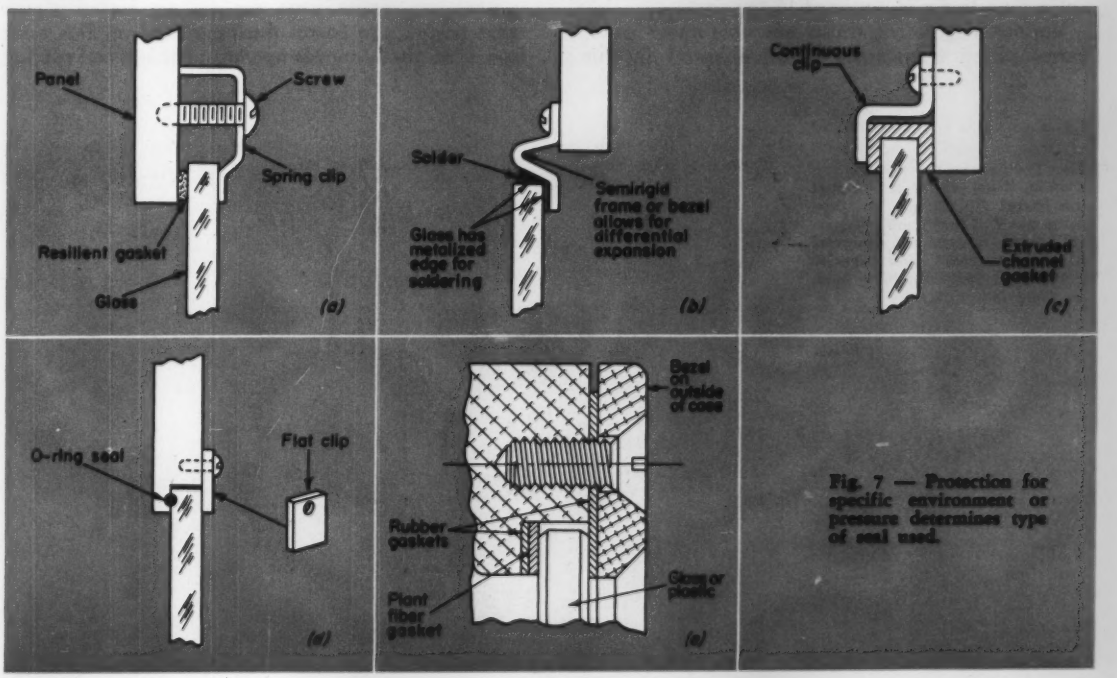


Fig. 7 — Protection for specific environment or pressure determines type of seal used.

Want an inexpensive method of producing high surface finishes or burnished effects on small parts of practically any material? Try

Precision Barrel Finishing

BARREL finishing is a process designed to remove burrs, edge roughness, and surface irregularities from bulk quantites of small and medium-size parts. Action of the rotating barrel causes friction between parts and a steady movement of the mass such that impact is reduced to a minimum. Addition of an abrasive material identifies the operation as "abrasive barrel finishing." This generalized term may be subdivided according to specific operations. Thus, the term "deburring" is used when the intended purpose is the removal of burrs and light flash projections, "cutting" or "cut-down" when improvement of surface is intended, and "burnishing" when very little metal is removed, but a high luster is imparted to the part.

Various degrees of finish are obtainable from a barrel-rolling operation. Abrasive barrel finishing with aluminum oxide chips can effectively remove sand, skin and fins from castings, and scale from forgings. This is a roughing procedure where fast cutting action of the abrasive is important. A more controlled operation, in which the cutting action of the abrasive is modified, removes not only light fin flashes, burrs, wire edges, and light scale, but also polishes the surface to remove rough spots, blend chamfers, and form radii. Finer control with different sizes and types of abrasives results in considerable improvement of surface finishes, radii contour, and color. An example of this control is the successful finishing of metal parts requiring a 3 to 7-microinch rms finish and a 0.0002-in. tolerance on radii.

Abrasion results from the sliding action of the mass within the barrel during rotation. The work load continually moves upward as the barrel rotates.

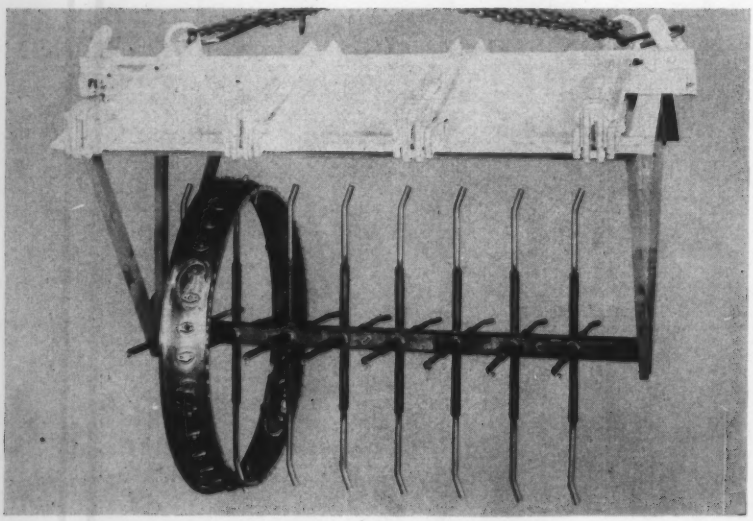


Fig. 1—Fixture for positioning a 48-in. diam jet-engine support for barrel finishing. Six supports are finished simultaneously. Such fixtures are designed for conventional and special barrel equipment for parts with intricate contours.

Photo, courtesy Almco Div., Queen Stove Works Inc.

LESTER F. SPENCER
Metallurgist
Centrifugal & Nuclear Pump Div.
Allis Chalmers Mfg. Co.
Milwaukee, Wis.

At a turnover point where the effect of gravity overcomes the tendency of the mass to stick together, the top layer slides, rather than falls, toward the lower part of the barrel. Although some abrading occurs as the work rises, about 90 per cent is accomplished during the slide. Because the parts and media are freely moving within the barrel, the same amount of finishing action occurs on each part during any given period of time.

Application: Barrel-finishing techniques are ideal for small to medium-size parts. However, workpieces weighing nearly 100 lb are being processed successfully. Pieces weighing from 6 to 8 lb and more may be processed without fixturing. Nicking is avoided by layering the parts in the barrel with chips or a chip mixture including rubber or hardwood blocks. Parts of intricate and critical contours are processed with the aid of special fixtures, Fig. 1. Stamped, cast, forged, extruded, and machined parts may be successfully processed. Materials include all types of ferrous and nonferrous metals and alloys, plastics, glass, ivory, wood, rubber, and ceramics.

Barrel finishing is economical because it requires little manpower with no specialized training. Also, it yields high productivity per hour per dollar value of equipment and minimizes rejects. Savings realized by a change-over to barrel finishing from other methods are shown in Table 1.[1]

Surface-finish uniformity is obtained only when the surface of the work is fairly uniform prior to barrel finishing. However, reasonable differences in size and heaviness of burr, flash, or other surface imperfections can usually be compensated for by adjustment of process variables. It is reasonable to expect that tumbling will not finish work areas that are shielded or inaccessible to media and load pressures. Such areas may require hand processing prior to barrel finishing.

Relation of Abrasive Size to Part Shape: A variety of media may be used for abrasive cutting, polishing, or burnishing, Table 2.[2] The liquid carrier, usually water, may contain organic detergents, soaps, rust

[1]References are tabulated at end of article.

Table 1—Savings Realized by Barrel Finishing

Type of Part	Previous Method of Finishing	Cost per Piece (dollars)	Cost per Piece (Tumbling) (dollars)	Cost Savings (per cent)	Annual Savings (dollars)
Zinc die cast	Wheel deburring	0.018	0.00017	99.1	6,633.00
Brass trim for plumbing fixtures	Polishing lathes	0.0264	0.00140	94.7	
Aircraft instrument	Burr bench	0.365	0.038	90.7	3,139.00
Stainless steel (aircraft)	Wire brush and bench grind	0.06	0.01	83.3	
Scale and food machine	Belt grinding	0.0045	0.000075	98.3	2,887.50
Gear	Hand filing	0.398	0.0635	84.0	6,680.00
Hardware	Buffing wheels	0.023	0.0017	92.6	2,130.00
Medical instrument	Hand polishing	0.0425	0.0005	98.8	3,750.00
Bronze-bearing wear plate	Sand paper	0.0831	0.0323	61.1	9,510.00
X-ray equipment	Special polishing machines	0.078	0.009	88.5	1,584.00
Tool and die	Sanding & buffing	0.14	0.0093	93.4	1,045.00
Aircraft	Lathe, buffing tools and wire brush	0.1040	0.0029	97.2	34,490.00
Screw machine	Belt sanding	0.00435	0.00011	97.4	3,930.00
Roller-bearing	Hand filing	0.40	0.05	82.5	5,000.00
Shoe-repair machine	Grinding wheel	0.049	0.0063	87.0	292.80
Oil burner	Buffing	1.80	0.90	50.0	2,000.00

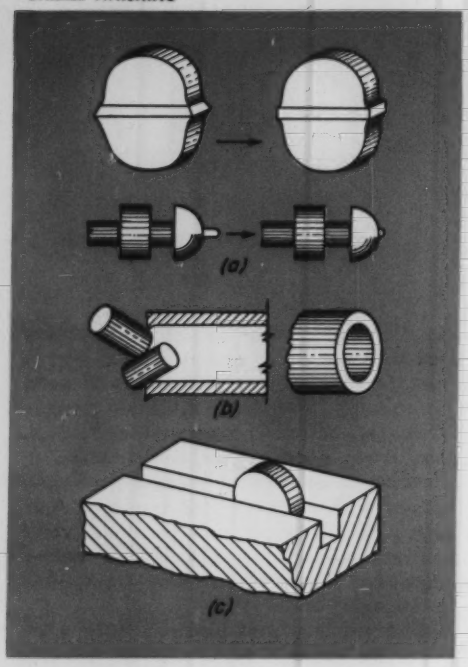


Fig. 2—Incomplete removal of fins and cutoff tips on cast parts by barrel finishing, *a*. Choice of abrasive medium and compound has little influence on such configurations. Such projections should be trimmed prior to tumbling. Cylindrical shaped abrasives, *b*, satisfactorily deburr tubing. Discs, *c*, are effective for removing burrs from slotted parts.

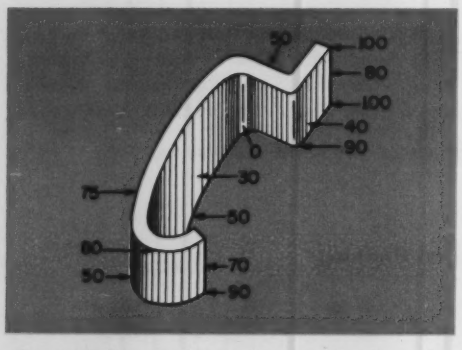


Fig. 3—Influence of part shape on abrasive action of tumbling medium. Figures show per cent of relative abrasion on various surfaces.

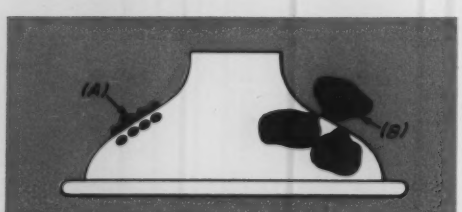


Fig. 4—Preferred abrasive medium size for thin-walled parts. Medium *A*, gives a better finish and also acts as a support for the shell. Medium *B* is likely to damage the shell wall.

or tarnish inhibitors, lubricants and protective colloids, cutting abrasives, and other additives.

Fine burrs are removed readily within a 2-hr deburring cycle. A heavy burr will be peened flat, and actual removal must ultimately be by grinding. To minimize this condition, economics dictate that cutting tools and dies be maintained sharp. Time cycles for deburring, grinding, polishing, and burnishing materials are shown in Table 3.[3]

Fins, sprues, and cutoff tips on castings and screw-machine parts are also of common occurrence. Complete elimination may frequently not be realized during tumbling even though optimum choice of abrasive and compound is made, Fig. 2*a*.[3] Where complete removal is required, parts should be trimmed with a die or snagged flush with the surface before tumbling.

One of the most troublesome configurations to barrel finish is a drilled hole, particularly when it is small. Where the tumbling medium is large compared to the hole, a burr will be bent into the hole rather than removed. A solution is to harden the part to obtain a brittle burr and thus permit it to break off. Or a mixed-size abrasive medium can be used to perform the deburring action.

Slots and burred tubes are almost as troublesome as drilled holes. In the cases of tubes, cylindrically shaped abrasives, Fig. 2*b*, perform satisfactorily. Flat steel discs, Fig. 2*c*, are very effective in deburring slots. To prevent lodging of abrasive within an opening, thickness of the medium should be less than the width of the slot (or diameter of the hole), but more than one-half the width or diameter.

In a deburring or grinding operation, the abrasive must move across the part under pressure. The greater this relative movement and pressure, the more rapid the cutting action. This action is seldom uniform over the entire surface of the part usually due to the shape being deburred, Fig. 3.[3] Exposed corners receive maximum action followed in order by exposed edges, convex surfaces, flat surfaces, large concave surfaces, small-radius concave surfaces, and slots and holes which may receive no abrasive action at all from the medium.

A small abrasive medium is effective for obtaining a smooth finish. As abrasive size increases, number of contact points decreases. Increased pressure on the parts surface results in increased cutting speed and a coarse finish. For thin-walled shells, Fig. 4,[2] medium size *A* is preferred since it will give the desired finish and also adequately support the thin wall. Medium size *B* is not recommended since there is a definite danger that larger particles will dent or otherwise deform the wall.

Abrasives and Compounds: Aluminum oxide is characterized by its hardness, resistance to fracture, and excellent cutting ability. It is used for rapid metal removal, often with a noncutting type of compound. A relatively rough finish is obtained which is preferred for parts that are subsequently painted. Surface finishes range from 50 to 100 microinches rms.

A degree of control is obtained by selecting proper grit size. Coarse grit produces a faster cutting action

Table 2—Tumbling Media

Media	Standard Size[1]	Operation	Abrasive Cutting[2]			Barrel Polishing[2]			Burnishing[2]		
			Ferrous	Nonferrous	Plastics	Ferrous	Nonferrous	Plastics	Ferrous	Nonferrous	Plastics
Aluminum oxide shapes	10 mesh to 2 in.	Wet	A	A	N	A	A	N	N	N	N
Aluminum oxide powder[3]	16 mesh and smaller	Wet or dry	A	A	B	A	A	B	N	N	N
Aluminum oxide (ceramic bonded)	1/8 to 2 in.	Wet	A	A	B	A	A	N	N	N	N
Bonded abrasive	1/8 to 2 in.	Wet	A	A	N	A	A	N	N	N	N
Granite chips[4]	1/8 to 1 1/4 in.	Wet	A	A	N	B	B	N	N	N	N
Flint stone[4]	1/8 to 2 in.	Wet	A	A	C	B	B	N	N	N	N
Quartzite[4]	Various	Wet	A	A	N	B	B	N	N	N	N
Marble[4]	Various	Wet	A	A	N	B	B	N	N	N	N
Limestone chips[4]	1/8 to 1 1/4 in.	Wet	A	A	C	A	A	N	N	N	N
Sand (builders')	8 mesh and finer	Wet or dry	A	A	C	A	A	C	N	N	N
Rolled zinc slugs	Various	Wet	BW	BW	N	AW	AW	N	A	A	N
Die-cast zinc slugs	Various	Wet	BW	BW	N	AW	AW	N	A	A	N
Soft steel balls & shapes	1/4 to 1/2 in.	Wet	BW	BW	N	AW	AW	N	N	N	N
Wood balls and shapes	Various	Wet or dry	BW[5]	BW[5]	AW	BW[5]	BW[5]	AW	A[5]	A[5]	A[5]
Veg. ivory chips	Various	Wet or dry	BW[5]	BW[5]	N	BW[5]	BW[5]	N	A	A	N
Nut shells	Mixed sizes	Wet or dry	N	N	AW	BW	BW	A	A	A	A
Hard steel balls & shapes	1/8 to 1/4 in.	Wet or dry	N	N	N	N	N	N	A	A	N
Glass burnishing balls	.....	Wet	N	N	N	N	N	N	—	A	—
Macerated corn cobs	Mixed, dust free	Dry	N	N	N	N	N	N	A	A	A
Leather scraps	Various	Wet or dry	N	N	N	N	N	N	A	A	A
Felt scraps	Various	Dry	N	N	N	N	N	N	A	A	A
Molded iron powder	.....	Wet	A	A	—	A	A	—	N	N	N

[1]Other sizes available for special applications. [2]Key: A, most used; B, often used or possible use; C, occasionally used for special applications; AW or BW, used with added fine abrasives; N, never used. [3]Usually mixed with other media but occasionally used alone. [4]Available in quarried state or processed to remove sharp corners. Quarried form only good for roughest operation. [5]With or without other media. [6]See wood balls.

Table 3—Barrel-Finishing Time Cycles (hr)

Operation For metal parts	Media → Granite	Limestone	Aluminum Oxide Shapes	Metal and Fine Abrasives	Metal and No Abrasives
Deburring[1]	1/4 to 12	.....	1/4 to 8	.....	.....
Grinding	8 to 48	8 to 48	4 to 100[2]	12 to 60	.....
Polishing (cut-down)	.....	1/4 to 16	1/4 to 6[2]	1/4 to 20	.....
Burnishing	.....	1/4 to 3[3]	.....	.....	1/4 to 3

For plastic parts	Media → Wood balls or shapes, nutshells, etc.
Cut-down	7 to 30
Ashing	4 to 50
Polishing	5 to 10
Lustering	2 to 10

[1]Average deburring time for machined or stamped steel is from 1 to 4 hr. [2]Heavier grinding is accomplished with synthetic abrasives. [3]Longer cycles are "abrasive burnishing." [4]Average time required to prepare zinc die castings through all operations is from 6 to 8 hr.

and large radii. Fine finishes and small radii require fine grits. These abrasives give surface finishes of 25 to 50 microinches rms.

Limestone has a comparatively mild cutting action and is used to tumble metals such as copper and zinc-base alloys. A disadvantage of this material is its reaction with either acid type or soap-base compounds. Where increased cutting action is desired, an abrasive compound is used.

Granite in combination with a noncutting type compound is used for polishing. The principle action is one of peening rather than grinding. When granite is used for deburring aluminum and copper-base alloys, magnesium, and steel, an abrasive compound is required to increase cutting action. Wear qualities are better than those of limestone.

Ceramic is a popular medium since it can be mol-

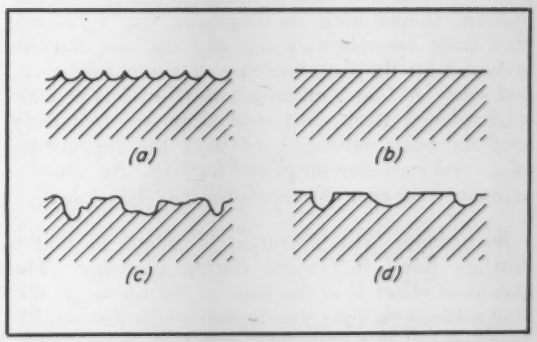


Fig. 5—Influence of initial surface condition on final finish. Surface *a* can be burnished by tumbling to a bright surface, *b*. Burnishing surface *c* will remove high spots but becomes ineffective thereafter and produces a dull finish, *d*.

ded into shapes such as spheres, triangular plates, and conical sections. Used with a noncutting or burnishing compound it produces a peening action.

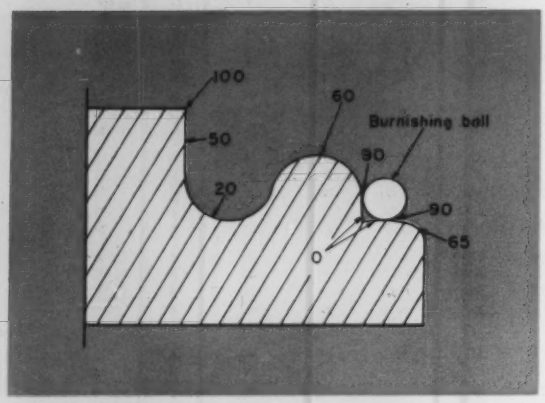


Fig. 6—Influence of part shape on burnishing action of balls. Figures show per cent of relative burnishing on various surfaces.

With the addition of an abrasive compound, the mild cutting action can be used for finishing all types of materials.

Other nonmetallic abrasives include pumice for the "ashing" operation on plastics; flint pebbles with or without an abrasive compound as an alternate for granite; molded abrasive slugs with a neoprene binder for finishing fragile work; wooden balls and shapes with or without an abrasive compound for tumbling plastics; and quartz honing stones that have good cutting action when used with suitable compounds.

Burnishing shot include case-hardened and highly polished balls, pins, and diagonals. These produce the highest luster obtainable in a tumbling barrel. A noncutting burnishing compound is used.

Metallic slugs frequently used for deburring include zinc and soft steel available in various sizes of uniform shapes such as diagonals, flat discs, etc. Zinc slugs are relatively soft and resilient and are preferred for the fine finishing of aluminum, brass, and steel. A 1 to 5-microinch rms finish is possible on hardened steel. Soft steel slugs are frequently used for brass castings, cast iron, the copper-base alloys and steel stampings and forgings. An abrasive or noncutting type of compound may be used.

Burnishing: This operation is unique in that a "surface flow" is realized during tumbling. The maximum effect is at the start of the operation and diminishes with time due to surface hardening. Effectiveness of this burnishing action is also proportional to the malleability of the material tumbled. It is possible to produce a bright shiny surface and a matte finish with the same rms finish. Also, a matte finish of about 30 microinches rms can be ball-burnished to a bright luster and still retain the same finish. The reason is that surface finish depends upon the initial surface condition. Thus, as shown in Fig. 5,[3] a relatively smooth surface *a* may burnish to a smooth, bright surface of a low rms finish, *b*. On the other hand, where the initial surface is rough, *c*, initial burnishing will flow the high spots. However, as the surface becomes hardened, further burnishing is ineffective. As a result, the surface instead of being mirror bright will have a "flat," unsatisfactory finish, *d*. A preliminary grinding operation will rectify this condition.

The effect of shape may also be an influencing factor in the degree of burnishing that can be obtained, Fig. 6.[3] Burnishing is more effective on uniform surfaces such as flat, spherical, or cylindrical shapes. Also, it is more effective on thick-gage stampings than on thin-gage stampings. This could be due to the reduction of unit pressure on the surfaces by the greater flexibility of the thin stock.

Nonmetallic Materials: Plastics and rubber products are also suitable for barrel finishing. An interesting example of a procedure used to remove fins from molded rubber products is dry rolling with dry ice to freeze the thin rubber sections, causing them to break off by impact.

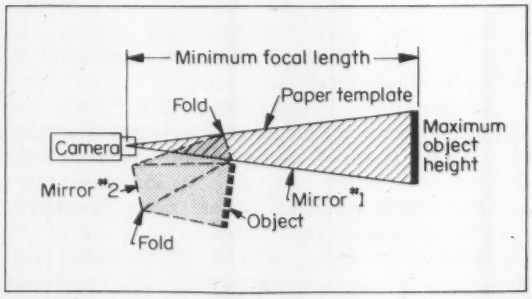
REFERENCES

1. Almco Div., Queen Stove Works Inc., Albert Lea, Minn.
2. H. Goldman—*Electroplating Engineering Handbook*, Reinhold Publishing Corp., New York, 1955.
3. A. S. Kohler—*Metal Finishing Guidebook*, Finishing Publications Inc., Westwood, N. J., 1959, pp. 185-223.

Tips and Techniques

Light Path Layout

A piece of paper, cut to the proper lens angle and minimum focal length as shown, can be conveniently used when laying out the light path for multiple-mirror panel systems.



The paper template can be folded at experimental angles to obtain optimum path angles and mirror positions. Each fold represents the exact required mirror size, position, and angle. — W. EDWARDS, *Electronics Test Div., NATC, Patuxent River, Md.*

Simplified procedure avoids trial-and-error steps in selecting . . .

Optimum Sections of TUBULAR COLUMNS

B. SAELMAN
Design-Weight Engineer, Lockheed Aircraft Corp., Burbank, Calif.

WHEN applied load and effective column length are known, the procedure outlined in this article enables direct selection of optimum sections for round tubular columns. There are no trial-and-error steps.

For a column of minimum weight, the optimum section is attained when the stresses corresponding to all possible modes of failure are equal. When no reserve margin of safety is required, these allowable stresses should be equal to the applied stress. Even though the various types of failures—Euler column, crippling, side-wise instability—result from the same compressive loading, interaction effects exist between these stresses and, for a more sophisticated analysis, should be taken into account.

Column Allowable Stress: The Euler column curve for any material can be readily obtained, and the tangent modulus equation should be used in the inelastic range.[1] That is,

$$\sigma_{col} = \frac{\pi E_t \rho^2}{L^2} \qquad (1)$$

where, for round tubes,

$$\rho = \sqrt{\frac{D^2 + (D - 2t)^2}{16}}$$

and, for tubes of high D/t ratio,

$$\rho = 0.35\,D$$

and[2]

$$E_t = \frac{\sigma_c}{\frac{\sigma_c}{E} + 0.002\,n\left(\frac{\sigma_c}{\sigma_2}\right)^n}$$

where

$$n = \frac{0.301}{\log \frac{\sigma_2}{\sigma_1}}$$

Crippling and Local Buckling Stress: Crippling stress refers to the ultimate stress that the cylinder can sustain and is assumed[3] to occur when yielding takes place. An equation for the crippling stress of thin round tubes in compression is[3]

$$\sigma_{cc} = E\,\frac{0.6\,\frac{t}{R} - \frac{R}{t(10^7)}}{1 + 0.004\,\frac{E}{\sigma_{ty}}} \qquad (2)$$

This equation is plotted in Fig. 1. It gives an average failure stress based on physical tests. Its limitations are described in its source.[3]

Stainless steel is frequently used for high-temperature and high-pressure systems involving round

Nomenclature

A	= Ratio P/σ_c, in.^{2}
B	= Ratio D/t
D	= Outside diameter, in.
E	= Young's modulus of elasticity, psi
E_t	= Tangent modulus, psi
L	= Effective column length, in.
n	= Stress-strain curve shape factor
P	= Applied load, lb
R	= Outside radius, in.
R_c	= Stress ratio in compression
t	= Wall thickness, in.
ρ	= Radius of gyration, in.
σ_c	= Applied stress, psi
σ_{cc}	= Crippling stress, psi
σ_{col}	= Euler column allowable stress, psi
σ_{cr}	= Local buckling stress, psi
σ_{ty}	= Tensile yield stress, psi
σ_1	= Stress corresponding to the intersection of the stress-strain curve with a line drawn parallel to the elastic portion of the curve from an offset of 0.001 strain, psi
σ_2	= Stress corresponding to the intersection of the stress-strain curve with a line drawn parallel to the elastic portion of the curve from an offset of 0.002 strain, psi

[1]References are tabulated at end of article.

tubular members in compression. One equation[4] for the crippling stress of stainless steel round elements is

$$\sigma_{cc} = \frac{E}{1000}\left(\frac{113}{\frac{D}{t}} - 0.0343\frac{D}{t} + 6.6\right) \quad (3)$$

Local buckling stress is given by $\sigma_{cr} = KE(t/R)$ where, for an ideal tube, $K = 0.606$ (steel) and $K = 0.617$ (aluminum alloy). However, due to the imperfections in real tubes, and depending on the assumptions that are made, K values ranging from 0.182 to 0.260 have been derived. In order to account for plastic effects, this equation has been proposed: $\sigma_{cr} = 0.20\sqrt{EE_t}(t/R)$.

Selection of Optimum Sections: The optimum section is derived from assumed existing crippling and column curves. Since the optimum section will generally have a high D/t ratio, the applied column stress is

$$\sigma_c = \frac{P}{A} = \frac{P}{\pi Dt} \text{ and } \rho = 0.35\,D$$

These equations yield

$$\sigma_c = \frac{(0.35)^2}{\pi}\left(\frac{P}{L^2}\right)\left(\frac{L}{\rho}\right)^2\left(\frac{D}{t}\right) \quad (4)$$

Observe that Equation 4 contains a loading factor P/L^2 and geometric factors L/ρ and D/t which are the same ratios against which the Euler column allowable stress and the crippling stresses are generally plotted. Hence, by using the following procedure a set of optimum curves for a given material can be developed:

1. Assume L/ρ.
2. Find σ_{col} corresponding to L/ρ from the column curve, Equation 1.
3. From the crippling curve, find D/t corresponding to $\sigma_{col} = \sigma_{cc}$ from Step 2 and Equation 2.
4. Solve for

$$\frac{P}{L^2} = \frac{(\sigma_{col} \text{ or } \sigma_{cc})\frac{\pi}{(0.35)^2}}{\left(\frac{L}{\rho}\right)^2\left(\frac{D}{t}\right)} \quad (5)$$

A set of optimum design curves for 2024-T4 aluminum-alloy extrusion is given in Fig. 2.

Example: Find the optimum section for a 2024-T4 aluminum-alloy round tubular column where $P = 100{,}000$ lb and $L = 20$ in.

From given data, ratio $P/(L)^2 = 250$ psi. From Fig. 2, $\sigma_{col} = 43{,}000$ and $D/t = B = 18$. Then:

$$A = \frac{100{,}000}{43{,}000} = 2.33 \text{ sq in.}$$

$$D = \sqrt{\frac{AB}{\pi}} = \sqrt{\frac{(2.33)(18)}{\pi}} = 3.65 \text{ in.}$$

$$t = \frac{D}{B} = \frac{3.65}{18} = 0.203 \text{ in}$$

If it is desired to maintain a specified amount of reserve strength, the set of curves in Fig. 2 can be used. Since $\sigma_c/\sigma_{col} = R_c$,

$$\sigma_{col} = \frac{(0.35)^2}{\pi}\left(\frac{1}{R_c}\right)\left(\frac{P}{L^2}\right)^2\left(\frac{L}{\rho}\right)^2\left(\frac{D}{t}\right) \quad (6)$$

Therefore, when a stress ratio R_c in compression is specified for reserve strength, enter the curve with $(1/R_c)\ P/(L)^2$ in lieu of $P/(L)^2$ and proceed as in the foregoing numerical example.

This article can be considered a companion to that in Reference 5 which provides for the optimum selection of sections for round tubes in bending.

REFERENCES

1. F. R. Shanley—"The Column Paradox," *Jour. Aero. Sci.*, Vol. 13, No. 12, Dec. 1946.
2. H. N. Hill—"Determination of Stress-Strain Relations from 'Offset' Yield Strength Values," NACA Technical Note 927, Feb., 1944.
3. L. H. Donnell—"New Theory for Buckling of Thin Cylindrical Cylinders under Axial Compression and Bending," *ASME Trans.*, Vol. 56, No. 8, Aug., 1954.
4. Michael Watter and Rush A. Lincoln—*Strength of Stainless Steel Structural Members as Function of Design*, Allegheny Ludlum Steel Corp., Pittsburgh, 1st Ed., 1950, p. 73.
5. B. Saelman—"Round Tubes in Bending," MACHINE DESIGN, Vol. 28, No. 19, Sept. 20, 1956, pp. 141-144.

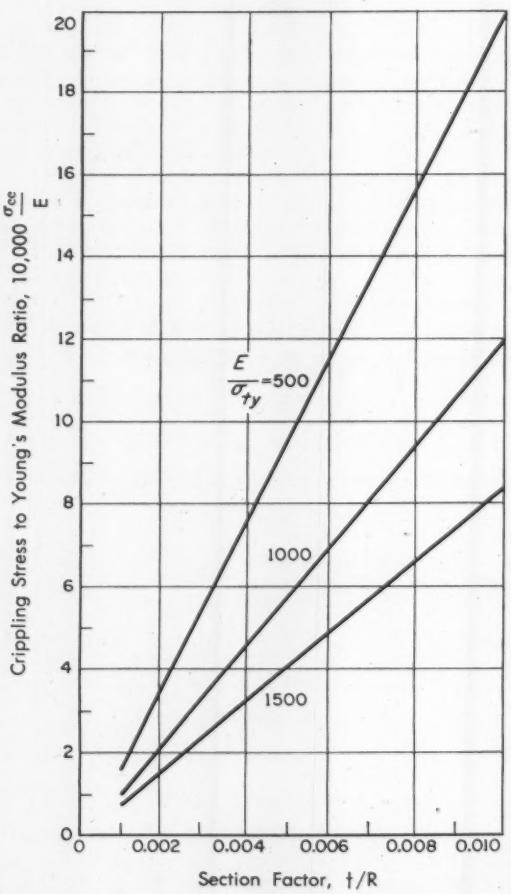


Fig. 1—Crippling stress of thin, round cylinders in compression, Equation 2.

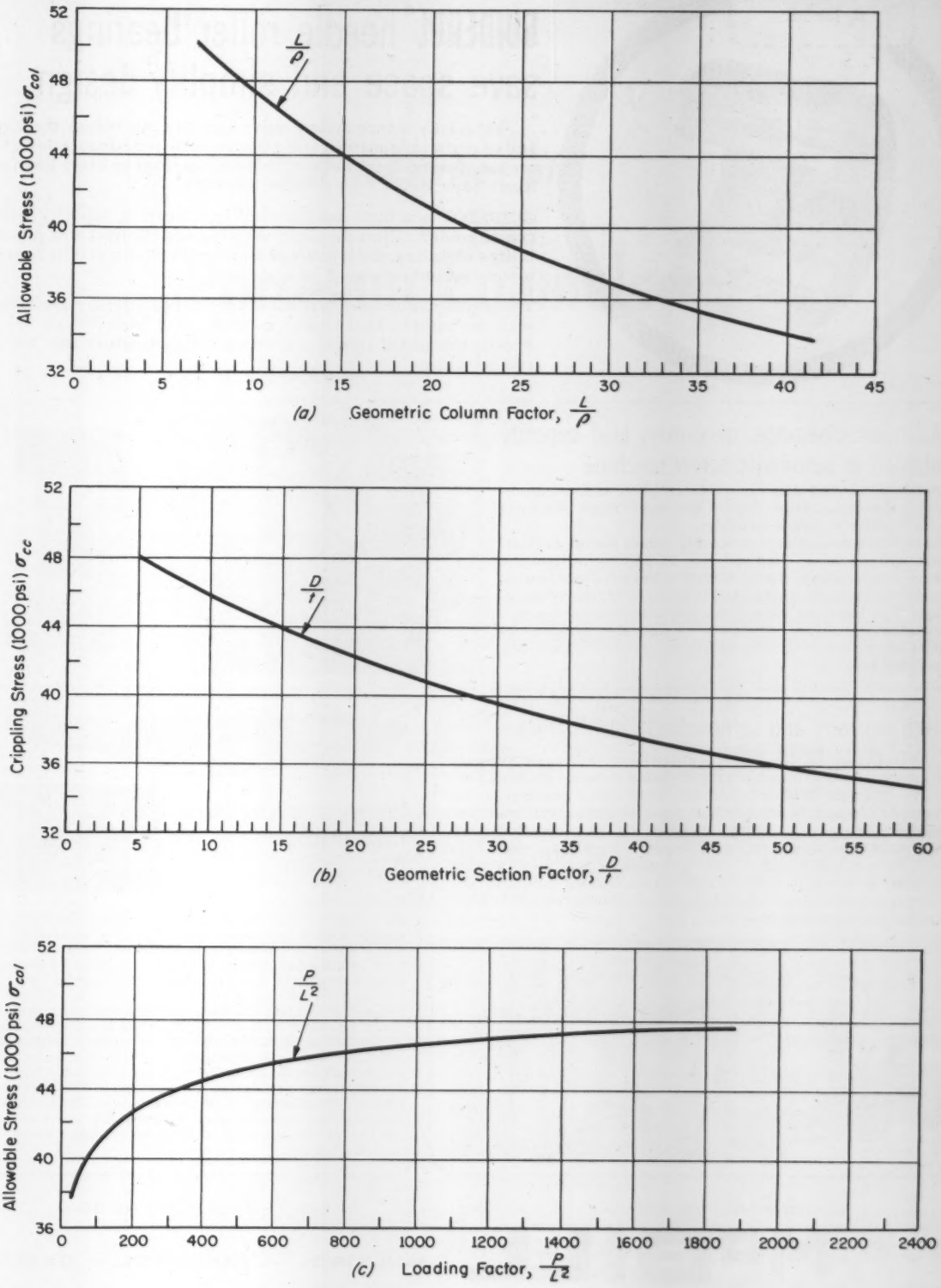
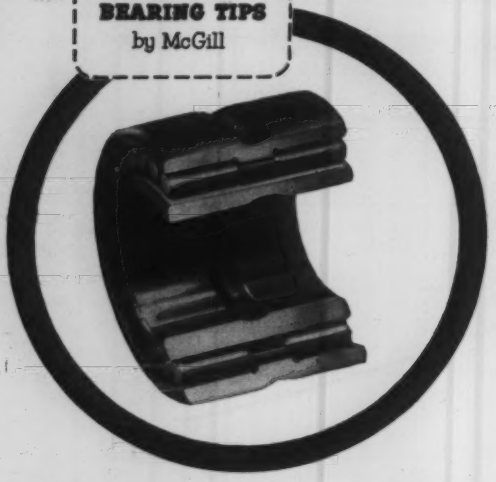


Fig. 2—Optimum ratios for round tubular columns of 2024-T4 aluminum alloy.

BEARING TIPS
by McGill



GUIDEROL® needle roller bearings save space and simplify design

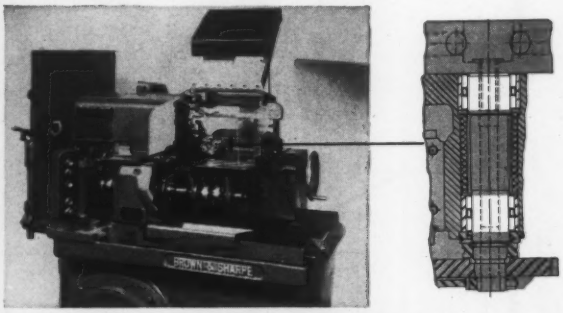
. . . especially where their greater capacity can reduce the size and cost of an adequate bearing housing. More and more designers are specifying McGill GUIDEROL bearings to carry heavier loads dependably with smaller bearings.

GUIDEROL bearings combine full type bearing capacity with center guided rollers that limit skewing and eliminate the possibility of binding under average misalignment. Especially suited to vertical mounting.

These precision heavy duty needle roller bearings are available with or without inner races in shaft sizes from ⅜" to 9¼". Specify the sealed series to keep out contamination and avoid relubrication.

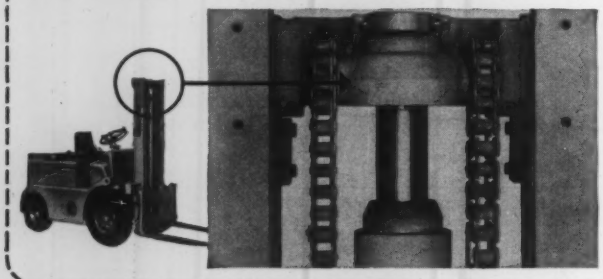
Minimum clearance, maximum load capacity retained in automatic screw machine

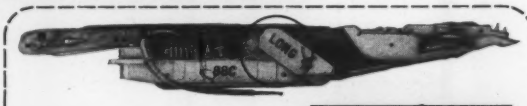
BROWN & SHARPE MFG. CO. replaced plain scraped bushings in the turrets of their No. 00 Automatic Screw Machines with McGill GUIDEROL bearings.
GUIDEROL bearings were selected to retain minimum clearance and maximum load capacity. In addition to meeting these requirements, the GUIDEROL eliminated production problems involved in the use of the scraped tapered bushings. The bearings support the turret during cutting and indexing operations. GUIDEROL design also satisfies the need for maintaining accurate alignment throughout long machine life.



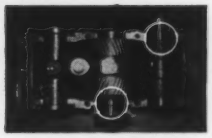
High capacity and compactness in lift truck chain cross-head rollers

GUIDEROL bearings support TOWMOTOR 6000 through 11,000 pound capacity lift truck payloads. They are used as chain crosshead roller bearings. Space requirements and the need for high capacity without the "walking" tendency of a straight needle roller bearing led to the selection of GUIDEROL bearings. GUIDEROL bearings have been rated very well in terms of length of life, maintenance and load carrying capacity in this application. Performance is rated excellent. The user reports reduced service requirements as compared with straight needle bearings formerly used.





Design simplified in mine machine transmission



Manufactured by the LONG Company, "PIGLOADER" coal loading machines feature full independent crawler control with a single motor. Application of GUIDEROL bearings on the tram clutch shaft is typical of other McGill bearing applications on the loader. GUIDEROL CT series bearings are used on the output end of the shaft to handle purely radial loads in small radial space. On the opposite end of the shaft, double row ball bearings handle combined thrust and radial loads. This combination eliminates the need for complicated adjustments. Use of a roller bearing, which has the same dimensions as the thrust bearing, accomplishes the design purpose with minimum machining variation in the transmission case. The GUIDEROL equipped tram transmissions allow each crawler to operate independently, a substantial design improvement.

engineered electrical products

McGILL®

precision needle roller bearings

SEND FOR CATALOG No. 52-A

MULTIROL — GUIDEROL — CAMROL

McGILL MANUFACTURING COMPANY, INC., BEARING DIV., 200 N. LAFAYETTE ST., VALPARAISO, INDIANA

Circle 493 on Page 19

Electrical properties of

Porcelain Enamels

C. G. BERGERON
Research Associate
University of Illinois
Urbana, Ill.

PORCELAIN enamels are used as insulation for wire conductors and motor starters, for encapsulating transformers, and in other areas where a high-temperature electrical insulation is needed. This paper presents data on room-temperature and elevated-temperature electrical properties of a conventional ground coat, a titania-opacified cover coat, and a composite of cover coat over ground coat, and compares the electrical properties of these enamels with those of currently used insulation materials.

Table 1 lists electrical properties of various insulating materials at room temperature and includes maximum usable service temperatures. It is of particular interest that the best organic materials are of little use at temperatures above 500 F. Fused silica has the highest continuous service temperature of the glassy materials, although the borosilicate glasses have maximum operating temperatures almost as high as that of fused silica.

Test Procedure: Electrical properties of the enamels were determined in the range from room temperature to 600 F. Ground-coated samples were prepared using a three-frit combination. Test plates of 22-gage enameling iron, 1½ in. sq, were sprayed with slip, dried, and fired at 1560 F for 2½ min. A cover-coat composition was sprayed directly onto similar plates, dried, and fired at 1550 F for 2½ min. For the composite samples, this cover-coat was applied over sample plates previously ground coated as described.

Specimens were placed in a shielded, electrically heated furnace. Resistance readings were made during cooling, and dielectric measurements were made during heating. Dissipation factor and capacitance were measured with a capacitance bridge, and the dielectric constant was calculated from capacitance, electrode area, and coating thickness. Coating resistance was measured with a dc amplifier and elec-

Table 1—Electrical Properties of Insulating Materials

Material	Dielectric Strength (v per mil)	Resistivity (ohm cm)	Max Service Temperature (F)
Teflon	450 to 900	10^{14}	400 to 500
Natural rubber	600	10^{16} to 10^{17}	167
Neoprene rubber	300	10^{12}	200
Silicone rubber	260 to 700	10^{14}	400
High-voltage porcelain	250 to 400	10^{13} to 10^{14}	1800
Mica	110 to 220	10^{13} to 10^{17}	1000
Fused silica	410 to 1000	10^{19}	2000
Borosilicate glass (electrical)	400 to 1000	10^{15} to 10^{17}	700 to 1800

Table 2—Dielectric-Strength of Porcelain Enamel

Coating Thickness (mils)	Trial →	Breakdown Voltage 1	2	3	Dielectric Strength, Avg. (v per mil)
Ground-Coated Specimens					
4.2		1200	1700	1200	325
4.4		1400	1200	1200	288
3.6		1100	1200	1100	315
3.1		1300	900	1800	410
2.6		1200	800	1200	385
Cover-Coated Specimens					
6.2		3000	3800	4200	590
4.9		1500	2200	3200	470
5.4		2200	3600	2200	495
5.0		2400	2000	1400	386

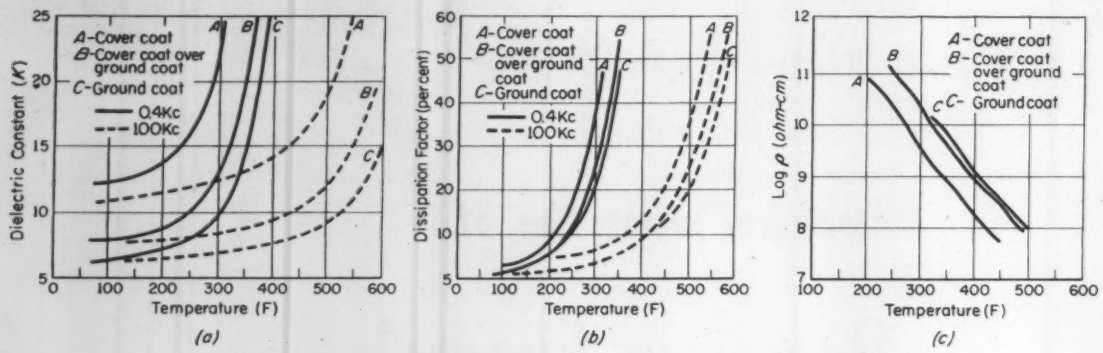


Fig. 1—Change in dielectric constant, *a*, dissipation factor, *b*, and volume resistivity, *c*, of porcelain enamels with increasing temperature.

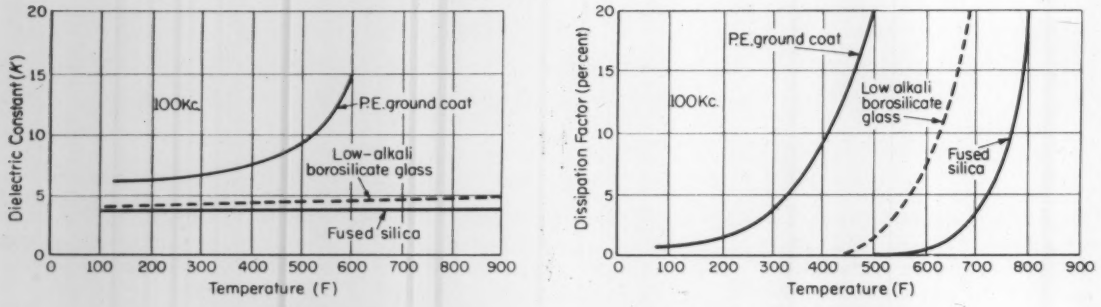


Fig. 2—Comparison of dielectric constant, left, and dissipation factor, right, for porcelain enamel and some insulating glasses.

trometer. Dc voltage across the specimen was less than 9.1 v in all cases. No measurable polarization effects were observed on reversal of polarity during the test. Dielectric strength of the coating was measured by applying 60-cps voltage in steps of 200 v with a given voltage applied to the coating for 1 min. Voltage was increased until the coating broke down.

Dielectric Constant: The change in dielectric constant with increasing temperature is shown in Fig. 1*a* for all three enamels at two different frequencies. At the lower frequency, dielectric constant for the three coatings increases rapidly with temperature, while at the higher frequency, temperature change is less. This type of behavior is characteristic of glassy dielectrics.

The dielectric constant for the ground coat is 6.2 at room temperature and that of the cover coat, 12.2. The combination of cover coat over ground coat gives values of dielectric constant which are intermediate to those of the individual enamels depending on relative thickness of cover and ground coats.

Dissipation Factor: The dissipation factor, Fig. 1*b*, also increases rapidly with temperature. At the lower frequency, change in dissipation factor with temperature is considerably greater than at the higher frequency. Values for the ground coat are less than those for the cover coat, and the combination of cover coat over ground coat gives values between the values for the individual enamels.

Resistivity: Fig. 1*c* shows the change in resistivity for these enamels with increasing temperature. Slopes of the respective curves are approximately equal; however, values for the ground coat are greater than those for the cover coat. The combination of cover coat over ground coat has resistivity values almost the same as those of the ground coat alone.

Dielectric Strength: Values are shown in Table 2. Three measurements were made for each of the five ground-coated specimens and four cover-coated specimens. There is considerable spread in the individual values obtained from any one sample. The ground coat has an average dielectric strength of 345 v per mil, and the cover coat, 485 v per mil. Dielectric-strength varies approximately inversely with the square root of thickness. Thus, a very thin specimen of material exhibits a higher dielectric strength than a thick specimen.

THERE MUST BE AN EASIER WAY

SUPPLYING BRANCHES AND SUBCONTRACTORS WITH BLUEPRINTS —IT'S EITHER A FAMINE OR A FEAST
WHAT'S THAT —WE DIDN'T SEND ENOUGH PRINTS FOR HALF YOUR MEN AT CAPE CANAVERAL?
LAST WEEK HE SENT 200 TO A GUY WHO NEEDED ONLY ONE
HOW DOES HE DECIDE—FLIP A COIN OR SPIN A ROULETTE WHEEL?
WE COULD THROW A BRAWL WITH THE AIR MAIL CHARGES ON THAT STACK MAZIE'S SENDING OUT
I KEEP TELLING HIM IF WE HAD A BLUEPRINTER MAKE AUTOPOSITIVE PAPER INTERMEDIATES WE'D ONLY HAVE TO SEND ONE OF THEM TO EVERYONE

Much easier for you, and much less costly, too, when you mail a Kodagraph Autopositive Paper intermediate instead of a bundle of blueprints.

These low-cost photographic intermediates, which can be made quickly by your local blueprinter or your own print room, end guesswork, waste and delays at both ends of the line.

Branches, subcontractors or customers receiving Kodagraph Autopositive intermediates get the equivalent of ink drawings. They can make as many sharp and clear whiteprints or blueprints as they need, when they need them. No running short, no stuffing the files. Any way you look at it, it's smart business to mail Autopositive intermediates.

Kodagraph
Reproduction Materials

New free booklet describes all the short cuts, savings, and improvements in print quality, which Kodagraph materials have brought to thousands of drafting rooms. Write for your copy today!

EASTMAN KODAK COMPANY
Graphic Reproduction Division, Rochester 4, N.Y.

MAIL COUPON FOR FREE BOOKLET

EASTMAN KODAK COMPANY
Graphic Reproduction Division, Rochester 4, N.Y.

Gentlemen: Send me a free copy of your booklet on Kodagraph Reproduction Materials. 19-9

Name_____

Position_____

Company_____

Street_____

City_____ Zone____

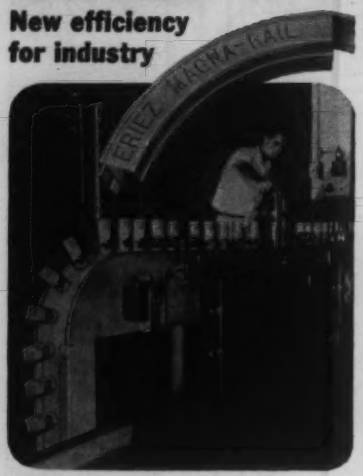
State_____

Kodak

MAGNETS
PLUS
AUTOMATION
EQUALS
MAGNAmation

New word from
ERIEZ

New efficiency
for industry



MAGNA RAILS. Lifetime powered, non electric magnetic elements that convert ordinary belt conveyors to *magnetic* conveyor elevators. Will convey ferrous items up inclines as steep as 90° — quickly, safely, with positive hold. Easily installed under existing lines, or incorporated into new equipment. Increases production. Reduces manpower needs. Saves valuable factory floor space.

VERSATILE MAGNA RAILS ARE AVAILABLE IN MANY MAGNETIC STRENGTHS IN VARIOUS BOLT-TOGETHER LENGTHS AND IN STRAIGHT AND CURVED SECTIONS, ASSURING YOU PROPER UNITS FOR SOLVING YOUR HANDLING PROBLEMS REGARDLESS OF SIZE OF PARTS.

Our men work closely with design engineers, OEMS, etc. If you need assistance, just contact us.

FREE! Big, 48-page booklet "Magnetic Ideas from Eriez". Loaded with idea-sparking illustrations, diagrams, installation photos. Send today!

FOR YOUR COPY, WRITE TO
Eriez Mfg. Co., 131WA Magnet Dr., Erie, Pa.

ERIEZ

Circle 495 on Page 19

The rate at which the potential gradient is applied has a pronounced influence on dielectric strength. A rapid increase in voltage results in values higher than those which occur when the voltage is applied more slowly or held at a given potential for a specified period of time before further increasing it. For these reasons, it is often difficult to compare dielectric strength data from different sources unless the test procedure and specimen thickness are known.

Comparison with Glasses: Fig. 2 shows dielectric constant and dissipation-factor values of the ground-coat porcelain enamel in relation to those of fused silica and a low-alkali borosilicate-type insulating glass. Dielectric properties of this particular ground coat are less stable with temperature than those of either of these two glasses. Porcelain enamels are essentially modified alkali borosilicate glasses and, as such, might be expected to approach a more desirable electrical property of the low-alkali borosilicate glass shown in Fig. 2.

For purposes of electrical insulation, porcelain enamels offer definite advantages over organic insulations in the higher temperature ranges. Although dielectric properties of porcelain enamels change markedly with increasing temperature, properties remain such that their usefulness as electrical insulation at high temperatures may still be quite satisfactory.

Proceedings of the Porcelain Enamel Institute Twentieth Annual Shop Practice Forum, University of Illinois, pp. 105-113.

electrical

Constant-Frequency Devices for Variable-Speed Forces

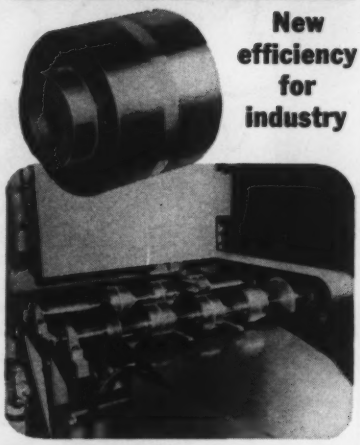
T. B. Owen, Santa Monica, Calif.

A discussion of variable-speed, constant-frequency devices using the mechanical differential. Methods of obtaining constant frequency are classified according to differential types which include constant-speed and constant-frequency output devices and nondifferential methods

MAGNETS
PLUS
AUTOMATION
EQUALS
MAGNAmation

New word from
ERIEZ

New
efficiency
for
industry



MAGNA ROLLS. Permanently powered, non electric automation units for use in magnetic conveying systems. Hold, control, elevate, change direction flow of ferrous materials — from small parts to large sheets. Can be used as head pulleys or in systems not utilizing belts. For *faster, shorter, safer* conveyor lines that move at peak speeds for peak production!

MAGNETIC STRENGTH IS GUARANTEED INDEFINITELY • NON ELECTRIC; NO WIRES, ATTACHMENTS, FUSES • NO MAINTENANCE • EASILY INSTALLED ON NEW OR EXISTING EQUIPMENT • LOW INITIAL COST; NO OPERATING COSTS • VARIOUS DIAMETER WIDTHS, STRENGTHS, CONTOURS, ETC., TO MEET SPECIFIC NEEDS.

Need assistance? Contact us; we work closely with design engineers, OEMS, etc., on models and pilot set ups.

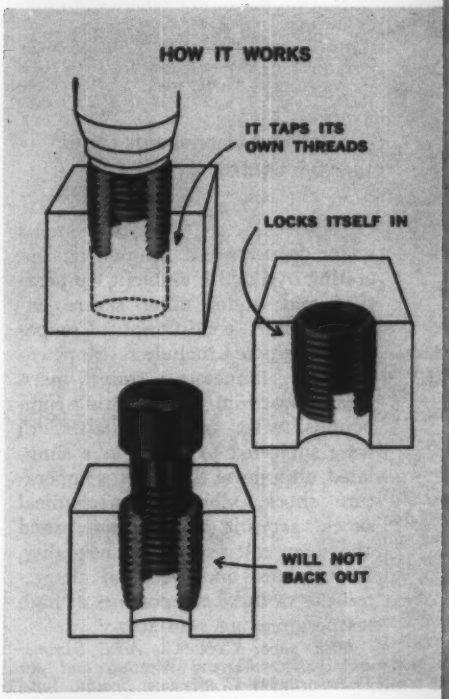
NEW! Free fully illustrated bulletin — "Eriez MAGNA-mation Components". Describes products and illustrates tried and proven installations. Send today!

Eriez Mfg. Co., 131-WB Magnet Dr., Erie, Pa.

ERIEZ

Circle 496 on Page 19

The quickest most practical way to put strong threads in soft materials the TAP-LOK® INSERT



FOR SOFTER METALS AND PLASTICS . . .
Slotted TAP-LOK insert has full V-form external threads to provide maximum locking torques; permits wide choice of mating hole sizes. Recommended for soft aluminum, zinc die castings, sand castings, and plastics. Meets requirements of MIL-MS 35914.

FOR HIGHER STRENGTH MATERIALS . . .
H-Series heavy-walled TAP-LOK insert has truncated root external thread and three-hole cutting edges for hard-to-tap higher strength materials and to meet MIL and other specs calling for Class 3B thread fit for gaging after installation.

FOR SPARK PLUG SOCKETS . . .
P-Series TAP-LOK insert was designed to eliminate thread wear and renew damaged threads in spark plug sockets in aluminum cylinder heads. Available from stock for standard plug sizes to meet most needs.

FOR WOOD . . .
W-Series TAP-LOK insert has coarse pitch external thread offering maximum strength in combination with ability to be driven into thin sections without splitting them. For furniture, cabinets, and other wooden parts where strong, permanent threads are needed, or which must be frequently assembled and disassembled.

The TAP-LOK® threaded insert taps its own thread and locks itself into the parent material in a single, quick operation. Designed as a permanent fastener in materials which are machinable but not strong enough to sustain applied loads in threads tapped directly into them, it is also widely used in harder metals and alloys where repeated assembly makes thread wear a problem.

Since TAP-LOK cuts its own threads, no additional assembly time is required, *making its installed cost the lowest of any threaded insert!*

Once installed, it is permanently locked in place, and will not back out under repeated heavy shocks or prolonged vibration. TAP-LOK inserts are available in the types shown at the right, in a variety of metals that include casehardened carbon steel, brass and 18-8 stainless steel (type 303). For complete information and prices, write Groov-Pin Corporation, 1130 Hendricks Causeway, Ridgefield, N. J.

TAP-LOK *Another fastener development from—* **GROOV-PIN CORPORATION**

Circle 497 on Page 19

BRIDGEPORT FORGINGS END "CASTING ABOUT" FOR BETTER PARTS

The benefits offered by forging in producing parts of virtually any size, far outnumber the advantages of other methods. Forgings have approximately 150% more strength than comparable castings, superior gas, air and water tightness; smooth fine-textured surface finishes; thinner walls with greater strength — thus saving on metals costs; close tolerances that enable positive chucking, reduced machining time; which means fewer tools and longer tool life. Forgings, being free from porosity, inclusions or other flaws, also cut down on rejects and costly inspection time.

Bridgeport has the facilities and experience to produce a wide range of aluminum, brass and bronze forgings — conventional, cored, solid, flat die and hot pressed — for a multiplicity of parts and assemblies. Forgings are particularly recommended for parts of complex design — irregular shape. In fact, forging often is the only technique by which many intricate parts can be produced.

Bridgeport's long experience with forgings of every description prompts our offer of Technical Service to manufacturers and fabricators on any metal parts problem. We work closely with manufacturers and our service often results in both savings and product improvement. Our new booklet, "Bridgeport Forgings," will give you the facts about this service. May we send you a copy? Write Dept. 3905.

CORED FORGING DIVISION

BRIDGEPORT BRASS COMPANY

1000 Connecticut Ave., So. Norwalk, Conn.

Specialists in Metals from **Aluminum** *to* **Zirconium**

such as frequency changers. Each of the types is covered generally. Efficiencies are evaluated and conclusions indicate that each type is equally satisfactory.

AIEE paper 59-780, *AIEE Summer and Pacific General Meeting and Air Transportation Conference, Seattle, June,* 1959, 8 *pp.*

Precision Power Frequency with Variable-Speed Generators

S. E. Rauch, University of California and L. J. Johnson, Hallamore Electronics Co.

Report on a system which can produce constant-frequency power efficiently from a variable-speed shaft without the usual mechanical complications. Electrical controls provide simple techniques for synchronizing multiple generators to a common line. Absence of feedback amplifier loops in the system eliminates transient variation in the frequency for load or speed changes. Essentially constant efficiencies over wide speed variations permit application of this apparatus to very large power units.

AIEE paper CP59-772, *AIEE Summer and Pacific General Meeting and Air Transportation Conference, Seattle, June,* 1959; 7 *pp.*

Electrical Components for a 600-F Control Circuit

K. A. Teumer, Sunstrand Aviation

Results of tests on components which were proved suitable for operating in a 600-F ambient temperature and under other severe environmental conditions. Components evaluated include resistors, capacitors, inductors, transformers, ceramic vacuum tubes, potting compounds, wire, and terminals. All were subjected to 650 F at a simulated altitude of 80,000 ft, temperature shock, vibration, mechanical shock, acoustic noise, ozone, sand and dust, salt spray, and humidity. Performance and electrical characteristics of these components at high temperature are satisfactory.

AIEE paper CP59-905, *AIEE Summer and Pacific General Meeting and Air Transportation Conference, Seattle, June,* 1959; 8 *pp.*

The Pros and Cons of Printed Circuits

D. MacGregor, Zenith Radio Corp.

Disadvantages of printed circuits culled from actual experiences in the radio-TV industry. The follow-

Circle 498 on Page 19

Park Lane by Oneida, Ltd.

Quality begins with Quality

...and Bridgeport Fine Grain Brass forms the basis for gracious Oneida Hollow Ware

The outstanding reputation enjoyed by Oneida Silversmiths, Oneida, N. Y., is attributable to one cause . . . quality. Since 1848, this company has designed and manufactured the very finest in silver flatware and hollow ware.

As the basis for many of their hollowware items, Oneida chooses Bridgeport Fine Grain Brass and Copper strip. These metals are subjected to severe deep drawing and stamping. Rigid inspection assures that each piece of Community fully meets the company's unqualified demands for "perfectionism." The grain of the copper and brass strip must be closely controlled to take the many polishing and buffing operations that follow forming. At the same time, the strip must be sufficiently ductile to take deep drawing and stamping without cracking or waving. Strip surface must be absolutely free of any imperfections.

Fine grain brass and copper are only two of the many closely quality-controlled alloys produced by Bridgeport for the *benefit* of hundreds and hundreds of products. Strip, for example, can be made to the most exacting tolerances and finishes from end to end on Sendzimir mills. Your production operations benefit by running with fewer interruptions when you use Bridgeport's long-length coils.

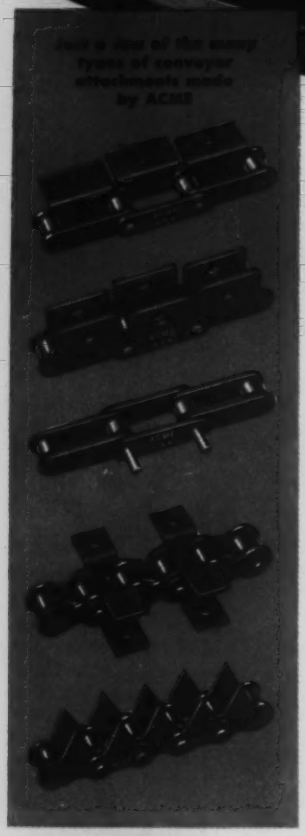
Behind Bridgeport's outstanding products and manufacturing facilities is Bridgeport Technical Service, ready to help with your product design and production. Technical Service – plus top quality strip, tube, rod and wire are a combination that can make your product better, your production methods more efficient. Call your nearest Bridgeport Sales Office or write to Department 4306 for your copy of our "Fine Grain" Brochure.

BRIDGEPORT BRASS COMPANY

Bridgeport 2, Connecticut • Sales Offices in Principal Cities

Specialists in Metals from Aluminum to Zirconium

How to SAVE MONEY on CONVEYOR CHAIN Attachments



By specifying Acme Standard Attachments wherever possible, a considerable saving in time and money can be made.

These low cost attachments are made to meet most ordinary requirements. They can be furnished individually, separate from the chain or they can be assembled into the chain either in riveted or detachable type.

SPECIAL CONVEYOR ATTACHMENTS

Possibilities for modification of Acme Standard Chains and Attachments are practically endless. In all adaptations, Acme engineers are skilled in retaining as many standard parts as possible to reduce cost, or design special attachments for your particular requirements. All Acme conveyor attachments and chains are available in standard, stainless steel or plated.

Write or call your local Industrial Distributors or our engineering department for time and money saving suggestions.

Write Dept. 6-Y, for new 100-page illustrated catalog, including new engineering section showing 36 methods of chain adjustments.

Call **ACME** for Service

Acme Chain Corporation
HOLYOKE
MASSACHUSETTS

COMPLETE LINE OF ROLLER CHAINS AND SPROCKETS • DOUBLE PITCH CONVEYOR CHAINS • STAINLESS STEEL CHAINS • CABLE CHAINS • FLEXIBLE COUPLINGS • STANDARD AND SPECIAL ATTACHMENTS

ing points are pertinent to design of printed circuits for many applications:

1. Heavy components such as transformers, electrolytics, and tuners frequently cannot be mounted on printed boards.
2. Entire sections of boards may burn out as a result of tube or component failure.
3. Some printed boards are not suited to high voltages.
4. Boards of the phenolic type become progressively embrittled as the curing process continues with time and high temperature. Replacing components may fracture the board.
5. Laminates do not tolerate the level of heat sometimes generated in a piece of electronic equipment.
6. If the board and components on it are handled carelessly, the conductor may peel from the board.
7. Some components are difficult and often impossible to remove without serious damage to other parts, the conductor, or the board itself.
8. Some repair operations cannot be made without special equipment obtainable only from the manufacturer of the particular model and then only if the entire board is first removed.
9. The foil conductor is susceptible to minute breaks which cause intermittent operation. This fault is difficult to locate and repair.
10. Printed circuits lack the performance of conventionally wired chassis with reference to sensitivity, drift, and residual ac hum.
11. Circuitry of etched boards is difficult to trace because shielding often obscures conductors.
12. Proper shielding in critical circuits is difficult with printed boards.
13. Capacity between conductors introduces design and performance limitations with printed boards.
14. Higher costs are incurred when special components are used to adapt the parts to board use.
15. Printed boards are inflexible, and circuit revisions are difficult until a new board is de-

signed, tooled, and produced.

16. If the product does not sell in scheduled volume, printed-board tooling increases unit costs as compared to similar circumstances with conventional wiring.
17. Designing for printed circuits requires more engineering time.
18. Humidity and "solder-tails" may contribute to voltage breakdown with certain printed boards. Sometimes there is insufficient space between foil conductors.
19. A printed board doesn't distribute and dissipate heat generated by tubes and other components as does a conventional metal chassis.
20. Alignment of tuned circuits may be adversely affected by changes in the dielectric constant of a laminated board. This happens as the resins dry out.
21. Dip-soldered connections often are faulty.
22. The combination of heat from tubes and the type of laminate board sometimes generates a noxious odor which is objectionable in home instruments or appliances.

The author admits that printed circuits have their place but presents the unfavorable side of the picture strongly to induce designers to study the problem more closely in light of facts gathered rather than from a personal feeling either for or against printed circuits.

IRE paper, IRE Third National Conference on Production Techniques, San Mateo, Calif., June 1959; 3 *pp.*

mechanical

Effects of Presetting Helical Compression Springs

T. J. Atterbury, Battelle Memorial Institute and W. B. Diboll Jr., Washington University

A procedure for predicting increase in fatigue load-carrying capacity due to presetting helical springs. The method is based on the actual stress-strain curve of a material. Reasonable correlation with experimental results is obtained. Presetting definitely increases the load-carrying capacity of springs in fatigue as well as static loading. Percentage in-

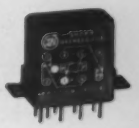
. . . they're both my babies

. . . but what a difference

Despite their identical appearance, those young innocents are barely fraternal. They *are* destined for fame, but along different Roads of Life.

The one on the left latches magnetically, eats only 50 mw. and works best in a circuit designed expressly with his characteristics in mind. He's also a few months older than his colleague, and has already made solid friends with at least one big military group. They like his particular combination of magnetic latching operation, high sensitivity, and ability to take 30 g's of vibration to 5000 cycles and 100 g shocks both on paper *and* in the flesh.

The little fellow on the right, on the other hand, offers a ready *replacement* suitable for existing equipment where standard DPDT switching is needed and the signal level is up around 200 mw. As such he's looking forward to making an even wider circle of friends than his companion — especially since he can take just as much vibration and shock and is put together with exactly the same care and high class materials.



Both of these hermetically sealed prodigies are described in their birth certificates which you can get for the asking. If you think the 50 mw., magnetic latching, left-hand one is for you, ask for the *Series* 32 specs; if it's the right-hand, "on-off" one you're interested in, specify *Series* 33. Don't try to go by looks — everything's coming in crystal cans these days.

* Sigma Corporate Image

SIGMA

SIGMA INSTRUMENTS, INC.
89 Pearl Street, So. Braintree 85, Mass.

AN AFFILIATE OF THE FISHER-PIERCE CO. (Since 1938)

Circle 501 on Page 19

Ring Seals by LINEAR

In Kel-F, Viton-A, Vyram, Polyurethane, and other unusual elastomeric materials having excellent resistance to many petroleum oils, synthetic lubricants, fuels, phosphate and silicate ester fluids—in a temperature range of —40° to +500° F.

LINEAR—specialists in close-tolerance molding in all of today's modern polymers . . . in both fabric reinforced and homogeneous materials.

These are automatic seals. For further help, call the LINEAR engineer.

PERFECTION IN RUBBER
LINEAR
LINEAR Inc. STATE ROAD & LEVICK ST. PHILA 35 PA.

Circle 502 on Page 19

crease depends on the material and amount of strain beyond the yield strength. The theory developed appears to adequately describe the increase in load-carrying capacity which can be realized if compensation is made for the parallel end turns after presetting, or if the end turns are reground after presetting.

ASME paper 59-SA-12, ASME Summer Conference, Blacksburg, Va., June, 1959; 4 pp.

A Mechanical Time-Delay Device Sensitive to Centrifugal Fields

J. R. Baumgarten, Whirlpool Corp. Research Laboratory and R. Cohen and A. S. Hall Jr., Purdue University

A proposed design of a mechanism suitable for use as a time-delay device which does not require electrical power. Power is derived from a centrifugal field. Equations of motion of the device are derived and effects of variation of certain design parameters are studied. Because of the assumptions in the derivations, results are intended only as a guide in design. The approximate solution yields results to within 10 per cent error only for systems with half-amplitude of 125 deg or less.

ASME paper 59-SA-9, ASME Summer Conference, Blacksburg, Va., June, 1959; 5 pp.

Creep of Thick-Walled Tubes Under Internal Pressure

F. P. J. Rimrott, The Pennsylvania State University

Derivation of equations for creep rates, strains, and stresses of a thick-walled, closed-end, circular, hollow cylinder under internal pressure. Cylinders are made of an isotropic and homogeneous material. Strains are considered large and require use of the finite-strain theory. Use of finite strains shows an important effect which is overlooked in methods assuming the usual small or infinitesimal strains. Assumption of infinitesimal strains leads to a prediction of wall thickness which is on the unsafe side.

ASME paper 59-APM-6, ASME Summer Conference, Blacksburg, Va., June, 1959; 5 pp.

Elastic-Plastic Shells Under Hydrostatic Compression

B. Paul, Brown University

Influence of the beam-column effect on carrying capacities of elastic

speedy fastener service

RIVETS • NAILS
THREADED PARTS

In Between Sizes • Lengths to 7 Inches • Close Tolerances • Special Heads • Any Metal including Monel • Inconel • Stainless

FAST DELIVERY...
SHORT or LONG RUNS...
DESIGN ASSISTANCE

Over 250 wire sizes in stock—from .024" up to ⅜" diameter—in 30 alloys . . . all geared to meet your requirements quickly to our usual high quality standards.

MANUFACTURERS
SINCE 1850

SPECIAL NAILS RIVETS SCREWS
Hassall
JOHN Hassall INC.
P. O. Box 2197 Westbury, Long Island, New York

Circle 503 on Page 19

shells submersed in a hydrostatic-pressure field. Specific problems include shells with clamped ends, simply supported ends, and combinations of these. In all cases, two characteristic modes of failure exist, corresponding to long and short shells. Terms "long" and "short" are unambiguously defined. Detailed results are presented graphically, and general conclusions are useful for design purposes.

ASME paper 59-APM-16, *ASME Summer Conference, Blacksburg, Va., June,* 1959; 8 *pp.*

Factors Which Influence Fatigue Life of a V-Belt

S. M. Marco and W. L. Starkey, Ohio State University and K. G Hornung, The Dayton Rubber Co.

Development of a new design method for V-Belts. The method involves a horsepower-life relationship derived from the results of an experimental program of belt testing. Study of these data introduces several new concepts of stress analysis for rubber-textile structures.

ASME paper 59-SA-18, *ASME Semi-annual Meeting, St. Louis, Mo., June,* 1959; 7 *pp.*

Pressure-Actuated Cylindrical Diaphragm Seals

C. Y. Neou, University of Bridgeport

Analytic formulas and charts for designing a thin-walled metallic cylindrical shell or band, welded peripherally on the inside of a valve body. The flexible sealing band can be inflated to provide a positive-contact seal when the valve is in a fully closed position and deflated to allow for contact-free seating and unseating of the valve disc.

ASME paper 59-SA-1, *ASME Semi-annual Meeting, St. Louis, Mo., June,* 1959; 9 *pp.*

Dynamic Analysis of a Cylindrical Cam

R. J. Sanella, Armour Research Foundation

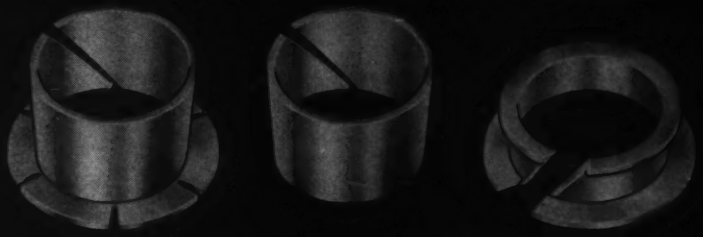
Developments of dynamic force and torque relationships for a cam follower restrained within a moving rotor and actuated by cylindrical cam. Mechanism operation is considered with the rotor having a constant angular velocity and also undergoing angular acceleration. A method is outlined to find torques and cam loads for actual problems, and an example is given. Two im-

Circle 504 on Page 19→

LONG LIFE, *THOMSON* "Snap-In"

NYLINERS®

of smooth, tough DuPont NYLON



Low Cost FLANGED Nyliner | Low Cost SLEEVE Nyliner | Low Cost DOUBLE-FLANGE Nyliner

BETTER BEARINGS THAT...

• COST LESS to BUY*
• COST LESS to INSTALL
& ELIMINATE LUBRICATION

Additional Benefits:

- CLOSE FIT
- LONGER LIFE
- EASILY INSTALLED
- LESS SERVICING
- SELF-RETAINING
- RESIST CORROSION
- LOW FRICTION
- RESIST POUNDOUT
- NO FRICTION OXIDATION
- DAMP VIBRATION
- OPERATE IN LIQUIDS
- NON-CONTAMINATING
- INSTANTLY REPLACEABLE
- RESIST ABRASION
- MINIMUM SPACE
- SILENT OPERATION
- LIGHTEST WEIGHT
- REDUCED WEAR

Engineered to Solve Problems . . . Improve Products . . . Reduce Costs!

NYLINER Bearings are a highly engineered thin liner of DuPont Nylon, designed to bring bearing users the many benefits of Nylon as a bearing material by solving most of the limitations surrounding its use. The compensation gap principle assures maintenance of diametral tolerances for precision applications.

Seven Standard Types available from stock. Write for literature and name of your local representative who stocks NYLINER Bearings for immediate shipment.

*In production quantities at new, REDUCED PRICES.

THOMSON INDUSTRIES, Inc.

DEPT. 4, MANHASSET, NEW YORK

Also— —Manufacturers of BALL BUSHINGS . . . the Ball Bearing for Linear Motions and 60 CASE . . . Hardened & Ground Steel Shafting

portant factors in a cam-follower configuration are quickly and easily determined—cam loads and power requirements. This type of calculation lends itself well to digital computer use. The computer can be used to calculate actual values for cam normal force for power requirements, and the problem can be programmed to handle "change over" conditions required throughout a calculation.

ASME paper 59-SA-3, *ASME Semi-annual Meeting, St. Louis, Mo., June,* 1959; 8 *pp.*

processes

Shear Spinning

B. N. Colding, Cincinnati Milling Machine Co.

Applications and advantages of a relatively new method for shaping metals by plastic deformation. The process uses a roller to deform metal plates plastically into conical or other shapes of circular cross section and may be technically described as shear spinning because of the sine-law condition. Technical data on the machine and tooling are included. Analytical expressions for shear-spinning stresses and tangential force are suggested on the basis of combined rolling and extrusion of the metal. Values for maximum theoretical reduction are derived for an ideally plastic material and for a typical strain-hardening material. Efficiency of deformation is investigated on the basis of experimental values of tangential force.

ASME paper 59-PROD-2, *ASME Production Engineering Conference, Detroit, Mich., May,* 1959; 12 *pp.*

TO OBTAIN COPIES of papers or articles abstracted here, write directly to the following organizations:

AIEE—American Institute of Electrical Engineers, 33 West 39th St., New York 18, N. Y.; papers 40 cents to members, 80 cents to nonmembers.

IRE—The Institute of Radio Engineers, 1 East 79th St., New York 21, N. Y.

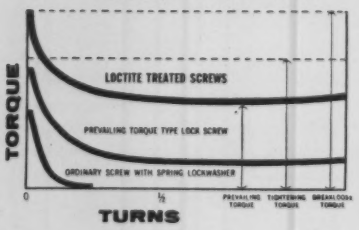
ASME—American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.; papers 25 cents to members, 50 cents to nonmembers.

Stake screws with LOCTITE ...a retaining compound designed for thread locking!

Insulating varnishes and mechanical punching have been widely used for years for the lack of a better method. Now there is a retaining compound designed specifically for thread locking. Consider these advantages:

1. LOCTITE provides complete resistance to loosening under shock or vibration because it fills and locks engaging threads, providing *both* breakloose and prevailing torque.
2. LOCTITE has several times the holding power of locknuts or lockscrews because locking action extends over entire engaged surface and persists for several turns.
3. LOCTITE is easy to apply . . . not sticky . . . no mess . . . does not air dry! Hardens only in absence of air. Large batches of threaded parts can be treated and stored for days . . . lock only when assembled. No heating or mixing is necessary.
4. LOCTITE comes in different strengths which apply any required locking torque—ranging from a light drag suitable for adjustment screws to a locking force exceeding the torsional strength of the screw. Provides greater uniformity than mechanical staking.

LOCKING CHARACTERISTICS OF LOCTITE



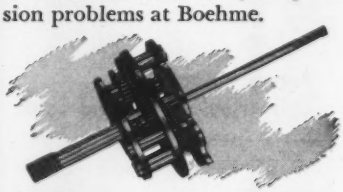
LOCTITE is a thin liquid that hardens when confined between closely fitting metal parts. It forms a tough, heat and oil-resistant, bond that secures threaded parts better than any mechanical locking device. Write for literature and free sample.

LOCTITE® SEALANT
AMERICAN SEALANTS COMPANY
111 Woodbine St., Hartford 6, Conn.
In Canada: J. S. Parkes & Co., Ltd., Montreal

Circle 505 on Page 19

PRECISION
DESIGN
ENGINEERING
MANUFACTURING

These are the constants in the Boehme equation for precision products: bold, original design, meticulous, resourceful engineering, and precision manufacturing processes, which combine to form the precision electrical, electro-mechanical and electronic products we furnish for the needs of this modern age of instrumentation and automation. Solve your precision problems at Boehme.

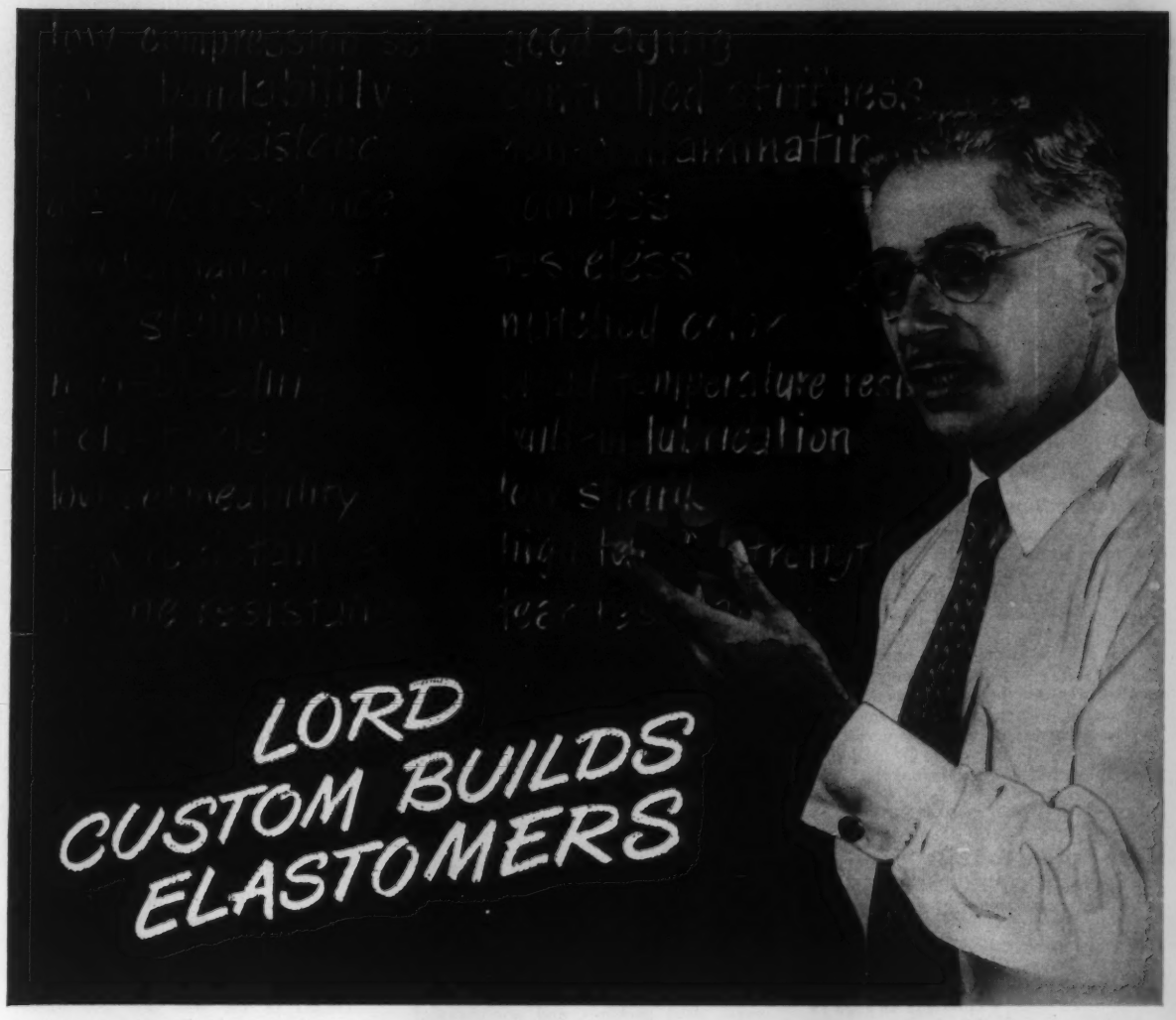


This gear train (300-1 in 6 steps) is typical of Boehme craftsmanship in the production of custom-made fine pitch precision gears. We have set precision standards in gear design and manufacture since 1917. Whatever your needs in custom-made precision gears—from ⅛" to 5" O.D., 180 to 16 D.P., up to A.G.M.A. Precision #3—Let Boehme craftsmanship and experience work for you.

Estimates, based on your blueprints or sketches are submitted without obligation. We welcome your inquiries.

H. O. Boehme, Inc.
Contractors, Designers, Manufacturers of Precision Electrical, Electro-Mechanical and Electronic Equipment since 1917
915 Broadway
New York 10, N. Y.

Circle 506 on Page 19



. . . to make your design ideas work

Does your new product design require an elastomeric material with special characteristics?

LORD can assist you by developing and manufacturing custom elastomeric parts—molded and bonded—to meet the most rigid specifications. Various combinations of the above properties can be incorporated to satisfy unusual designs, special configurations, severe operating conditions.

LORD capabilities include thorough knowledge of all modern elastomers, special skills in creating custom formulations, complete testing and production facilities and exceptional success in solving difficult assignments. Superiority of the LORD rubber-to-metal bond is common knowledge.

For custom-built elastomers to translate your idea into a profitable new product, contact the nearest LORD Field Office or the Main Office, Erie, Pennsylvania.

LORD®
BONDED RUBBER

FIELD ENGINEERING OFFICES

ATLANTA, GEORGIA · CEdar 7-9247
BOSTON, MASS. · HAncock 6-9135
CHICAGO, ILL. · Michigan 2-6010
DALLAS, TEXAS · Riverside 1-3392
DAYTON, OHIO · BAldwin 4-0351
DETROIT, MICH. · Diamond 1-4340
KANSAS CITY, MO. · WEstport 1-0138
LOS ANGELES, CAL. · HOllywood 4-7893
NEW YORK, N. Y. · Circle 7-3326
PHILADELPHIA, PA. · PEnnypacker 5-3559
SAN FRANCISCO, CAL. · EXbrook 7-6280
WINTER PARK, FLA. · Midway 7-5501

"In Canada—Railway & Power Engineering Corporation Limited"

LORD MANUFACTURING COMPANY · ERIE, PA.

Circle 507 on Page 19

Helpful Literature
for Design Engineers

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Hydraulic Pumps

Thyco variable volume radial piston pumps and controls are available in 18, 50, and 200-gpm sizes, rated at 3000 psi, and capable of delivering 5000 psi maximum. Controls for these pumps are also covered in three illustrated bulletins. 4, 4, and 6 pages. Texas Hydraulics, Inc., 5000 Research Blvd., Austin, Texas. P

Circle 631 on Page 19

The International Inch

The significance of the changeover to the International Inch is explained in a common-sense manner in bulletin entitled "The New International Inch . . . and How It Will Affect Your Operations." Chart is included to aid in converting U. S. Inches to International Inches, and to enable designers to determine whether the old and new inches will be significant on a job involving specific dimensions and tolerances. 8 pages. Pratt & Whitney Co., Charter Oak Boulevard, West Hartford 1, Conn. B

Circle 632 on Page 19

Quick-Release Fastener

Bulletins P-1, P-2, and P-3 contain dimensions, specs, and other information on Pres-Loc quick-release fasteners for sheet metal assemblies. 1 page each. Deutsch Fastener Corp., 14504 S. Figueroa St., Gardena, Calif. L

Circle 633 on Page 19

Spot Weld Fasteners

Complete information on the design and application of nuts, screws, pins, and other parts for spot weld attachment are presented in Bulletin 595. Weld settings and assembly techniques as well as design considerations are covered. 6 pages. Ohio Nut & Bolt Co., 33 First Ave., Berea, Ohio. G

Circle 634 on Page 19

Damper Regulator

Developed to control medium pressure boilers for up to 150-psi service, the No. 5000 damper regulator is also usable to control fans, stokers, and valves. Performance data are contained in Bulletin DR 1-59. 2 pages. Atlas Valve Co., 280 South St., Newark 5, N. J. D

Circle 635 on Page 19

Air & Hydraulic Valves

The new line of FX Quick-Dump piloted valves is designed for pneumatic and hydraulic service at pressures to 125 psi. Two, three, and four-way types for use in temperatures from −65 to 225° F are detailed in Bulletin 359. These nonelectric valves are offered normally open or normally closed for in-line and original equipment installation. 2 pages. General Gas Light Co., Humphrey Products Div., 202 N. Park Ave., Kalamazoo, Mich. H

Circle 636 on Page 19

Temperature Regulator

Described in Data Sheet F-9310 is a new self-contained temperature regulator for the proportional control of water, gas, or low-pressure steam. Sizes range from ¼ to 4 in., band calibrated motor operator is designed for 115-v 60-cycle ac. 1 page. Barber-Colman Co., 1300 Rock St., Rockford, Ill. K

Circle 637 on Page 19

Centrifugal Castings

Centrifugal castings for unfired pressure vessels, radioactive system service, and other critical applications are subject of Bulletin 300. Information on designing, specifying, and buying hollow cylindrical or tubular parts is presented. 16 pages. Sandusky Foundry & Machine Co., Sandusky, Ohio. G

Circle 638 on Page 19

Packings

Prices, physical properties, available sizes, recommended services, and other data on self-lubricated packings for rods and pistons of air and hydraulic equipment, sheet packings, and nonlubricated packings and gaskets are contained in illustrated 1959 Catalog. 36 pages. Greene, Tweed & Co., North Wales, Pa. E

Circle 639 on Page 19

Counters

Mechanical, magnetic, predetermining, convertible, and reset type tally counters are briefly described in Condensed Catalog. Included is card to facilitate requesting more detailed literature on counters for specific applications. 4 pages. Veeder-Root Inc., Hartford 2, Conn. B

Circle 640 on Page 19

Snap-Action Switches

In addition to general purpose, low-force, high-sensitivity, open-blade, environment-free, metal-cased, AN and JAN, direct-current, and reset switches detailed in Catalog 359, information is provided on new sealed units for severe environments and low-cost switches for automatic devices and appliances. 28 pages. W. L. Maxson Corp., Unimax Switch Div., Ives Road, Wallingford, Conn. B

Circle 641 on Page 19

Drafting Supplies

Included in 1959 Catalog of drafting, engineering, and artists' materials are descriptions of bulletin and black boards, drawing boards and tables, T-squares and straightedges, triangles and curves, scales, protractors, templates, and slide rules. Single and quantity prices are included. 36 pages. Lutz Co., Guttenberg, N. J. D

Circle 642 on Page 19

Variable Transformers

Design features of the new 10B Series of Powerstat variable transformers for 120-v 50/60-cycle service and with output to 2.5 amp are explained in Bulletin P159. 8 pages. Superior Electric Co., Bristol, Conn. B

Circle 643 on Page 19

Semiconductors

Literature available on semiconductors consists of data sheets on the Model TA-11 thermoelectric junction, Type HR-31 solid state Halltron, the MS-41 Magnetoresistor, the Model MC-1 magnetic circuit, and the HS-51 solid state device. Items are of interest to circuit designers and research engineers. Ohio Semiconductors, Inc., 1035 W. Third Ave., Columbus 8, Ohio. G

Circle 644 on Page 19

Variable Speed Drives

Details of the new Size 500 Motodrive added to the Reeves line of variable speed drives are given in Catalog M-592. Also presented are data on Motodrives in ¼ to 40-hp ratings, with output speeds from 1.8 to 4660 rpm, and with speed ranges from 2:1 to 10:1. 8 pages. Reeves Pulley Co., Columbus, Ind. J

Circle 645 on Page 19

Dacron V-Belts

Performance and test curves on V-belts reinforced with Dacron polyester fiber are included in information given in Folder A-11303. Advantages of this construction are explained as compared with other reinforcing materials. 6 pages. E. I. du Pont de Nemours & Co., Textile Fibers Dept., Wilmington 98, Del. C

Circle 646 on Page 19

Machining of Aluminum

Tables and recommended speeds and feeds for forming, turning, drilling, boring, reaming, and cutting off of aluminum are tabulated in file chart Sec. G, No. 2. Cutting speed conversion table is included. Peter A. Frasse & Co., 17 Grand St., New York 13, N. Y. D

Circle 647 on Page 19

FAWICK Type ER Clutch installed on main drive of Milnor Automatic Washer-Extractor.

Fawick Clutches here...

mean fast, accurate cycling HERE!

Milnor Automatic Washer-Extractor which automatically cycles washing, rinsing, and damp drying laundry operations.

Both manufacturers and users of commercial automatic laundry washers know that their success depends on fast, accurate cycling of their equipment.

That is one major reason why the Pellerin-Milnor Corporation, New Orleans, La., uses FAWICK Clutches on the main drives of their famous Milnor Automatic Combination Washer-Extractors.

The FAWICK ER Clutches on these machines respond instantly to programmed controls, supply full torque to the work load—with continuous "new clutch" performance over a long, maintenance-free life.

This is but one of hundreds of installations on a wide variety of mechanical products where FAWICK provides the best answer to power transmission requirements.

For full details on the advantages FAWICK can bring to the operation of your equipment call or write your nearest FAWICK representative or the Home Office, Cleveland, Ohio.

FAWICK AIRFLEX DIVISION
FAWICK CORPORATION
9919 CLINTON ROAD • CLEVELAND 11, OHIO
Fawick Canada, Ltd., 60 Front St., West, Toronto, Ont., Canada

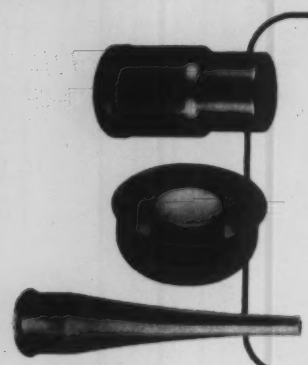
FAWICK AIRFLEX

INDUSTRIAL CLUTCHES AND BRAKES

Circle 508 on Page 19

Schrader Metal Spinnings & Hydroformings

• CUT TOOL AND DIE COSTS
• HOLD CLOSE TOLERANCES



PUMP COVER
⅛" stainless machined to ±.005.

STAINLESS STEEL SHROUD
Radius and dia. held to ±.001.

COPPER RESISTOR HOUSING
Wt. is ±¼ oz. on finished part.

Schrader engineers have had extensive experience in producing odd shapes, short runs, and experimental parts with a minimum of set-up and tooling costs.

Write for Brochure
Dept. MD-7

Since 1897

J. Schrader Company
4603 FENWICK AVENUE, CLEVELAND 1, OHIO

Circle 509 on Page 19

SLOW MOTION IS OUR BUSINESS

NEW!

Brevel "F" motors have **fully-enclosed gear trains;** provide maximum protection of gears against dirt.

Designed to give maximum power transmission at lowest noise level by use of specially cut helical gears. Optional features—brake, clutch, and cooling fan—make it suitable for a wide variety of applications. Like all Brevel Motors, this new "F" Motor provides reliable power at low cost.

Write, wire, or phone today for Catalog 28R. You will receive information on Brevel's complete line of small gear head motors.

BREVEL

Brevel Products Corp. • 615 West 26th St., New York 1 • Phone: WAtkins 4-4737

HELPFUL LITERATURE

Heat Exchangers

Set forth in Bulletin B-20 are all design and application data necessary to select and apply standard exchangers for a wide range of services. Six types are described in sizes ranging up to 1200 sq ft of surface. They are made of carbon steel, with nonferrous tubes, and in stainless. Thermal design charts and formulas supplement text. 20 pages. Struthers Wells Corp., Warren, Pa. F

Circle 648 on Page 19

Wire & Strip Forming

How to achieve lower wire products parts costs is theme of guide on wire forming, strip forming, and cold heading and threading. Company supplies wire products from 2 in. long to some requiring 12 to 14 ft of wire. Strip up to 3 in. wide can be formed. 4 pages. Robertson Steel & Iron Co., 71 Elm St., Cincinnati 2, Ohio. G

Circle 649 on Page 19

Miniature Toggle Switch

Measuring only ½ x ½ in. at the base and weighing only 4½ gr, the 2TM1-T toggle Micro Switch is for use on aircraft panels, geophysical equipment, and transistorized devices. It is rated 7 amp, 28 v dc resistive, up to 75,000 ft. Data sheet 158 provides details. 2 pages. Minneapolis-Honeywell Regulator Co., Micro Switch Div., Freeport, Ill. K

Circle 650 on Page 19

Motor Catalog Changes

Catalog pages D-4 and D-13 which incorporate several changes are offered to replace all previous dc-section pages bearing these page numbers. D-4 has been changed from shunt motors to 25 per cent compound wound. Listed are horsepower ratings, speed, frame types, NEMA numbers, voltage ratings, and other data. 2 pages each. Baldor Electric Co., 4351-67 Duncan Ave., St. Louis 10, Mo. I

Circle 651 on Page 19

Engines & Power Units

Catalogs BU-528 and BU-531 reveal the design, engineering, and performance capabilities of the G-149 and G-226 engines and power units. Units are respectively rated 45 bhp at 2000 rpm and 67 bhp at 1800 rpm. Maximum torques are 129 lb-ft at 1300 rpm and 211 lb-ft at 1100 rpm. 8 pages each. Allis-Chalmers Mfg. Co., Material-Handling Div., Milwaukee 1, Wis. K

Circle 652 on Page 19

Textured Metals

Eight new patterns in textured metals are illustrated in folder along with typical applications in which textured metals show up. Metals are available perforated and nonperforated in a variety of finishes, including plated, painted, polished, preclad, porcelain enameled, vinyl-laminated and anodized types. 6 pages. Ardmore Products, Inc., Aldene Road & First Avenue, Roselle, N. J. N

Circle 653 on Page 19

Electric Tachometers

Electric tachometers for a variety of uses in transportation, industrial processing, production control, machine tools, marine equipment, testing, and lab work are reviewed in folder. Generators for use with tachometer indicators are also covered. 4 pages. Electro-Mechano Co., 241 E. Erie St., Milwaukee, Wis. K

Circle 654 on Page 19

Epoxy Products

Condensed catalog gives properties, applications, and prices of Helix epoxy products as well as details of accessories for use in production where epoxy bonding agents, potting compounds, sealants, and coatings are used. 4 pages. Carl H. Biggs Co., 1547 14th St., Santa Monica, Calif. L

Circle 655 on Page 19

Drafting Templates

Set of five drafting templates allows speedy tracing of standardized, right-angle gear drives. They consist of plan and end view drawings of 1/3, 1, 2¼ and 5-hp Anglegear models. Airborne Accessories Corp., Marketing Dept., 1414 Chestnut Ave., Hillside 5, N. J. D

Circle 656 on Page 19

Nickel-Base Alloy

Hastelloy nickel-base alloy N, developed as a container material for molten fluoride salts, resists embrittlement upon continuous exposure to 1600° F. It has good weldability and can readily be forged. Developmental data and properties are listed in Bulletin F-30. 12 pages. Haynes Stellite Co., Kokomo, Ind. C

Circle 657 on Page 19

Printed Circuit Tapes

Pre-cut printed circuit tapes and shapes, backed with self-sticking adhesive, are available in a wide range of sizes and shapes for use in printed circuit layout and production. Prices and applications are covered in Bulletin 163-D. 4 pages. W. H. Brady Co., 727 W. Glendale Ave., Milwaukee 9, Wis. K

Circle 658 on Page 19

Engine Starting Controls

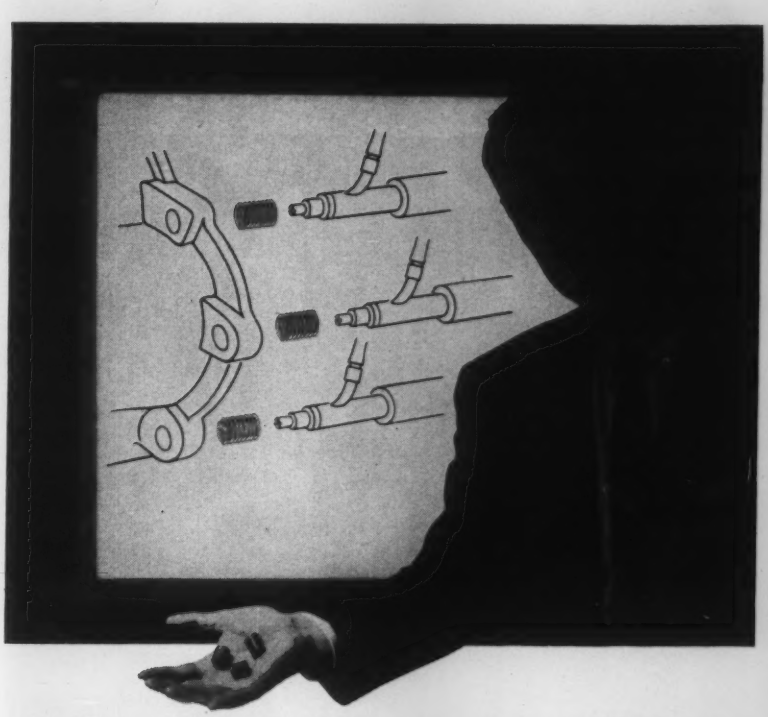
Supplementary Data Section 6, Bulletin 1025-134 affords complete data on automatic engine starting controls designed to respond at 50 per cent of normal battery voltage. Associated control equipment, including automatic transfer switches and solenoid valves, are also covered. 6 pages. Automatic Switch Co., Florham Park, N. J. D

Circle 659 on Page 19

Floodlights

Miniature edition of floodlight catalog includes original material on selecting floodlights, general purpose floodlights, heavy duty floodlights, mercury vapor and special floods, lighting for hazardous locations, searchlights, underwater lighting, poles, and accessories. Request Bulletin 2714. 184 pages. Crouse-Hinds Co., Syracuse 1, N. Y. N

Circle 660 on Page 19



"These Heli-Coil® Inserts give aluminum tapped holes the strength of steel threads in the new FORD transmission housing."

Threads in the starter mounting pad in the new Ford aluminum transmission housing would have been too soft to resist wear under vibration, impact and removals of the starter for service. ***Heli-Coil*** steel wire inserts eliminate this problem, are installed automatically with ***Heli-Coil*** designed equipment.

Now you can design aluminum assemblies and provide permanent internal steel threads for use with steel screws or studs. And ***Heli-Coil Corporation*** also supplies high-speed, automatic installation equipment to meet mass-production schedules economically.

Opening the door to exciting new design possibilities, *Heli-Coil* Inserts:

- hold fasteners secure under impact and vibration
- prevent thread wear, stripping, corrosion, galling and seizing
- allow repeated assembly and disassembly without loss of thread strength
- can be used in standard proportion bosses without need for redesign
- are available in a complete range of U.N.C. and U.N.F. thread sizes as well as spark plug and pipe thread series
- save assembly time, space, weight and cost
- have full industrial and military approval

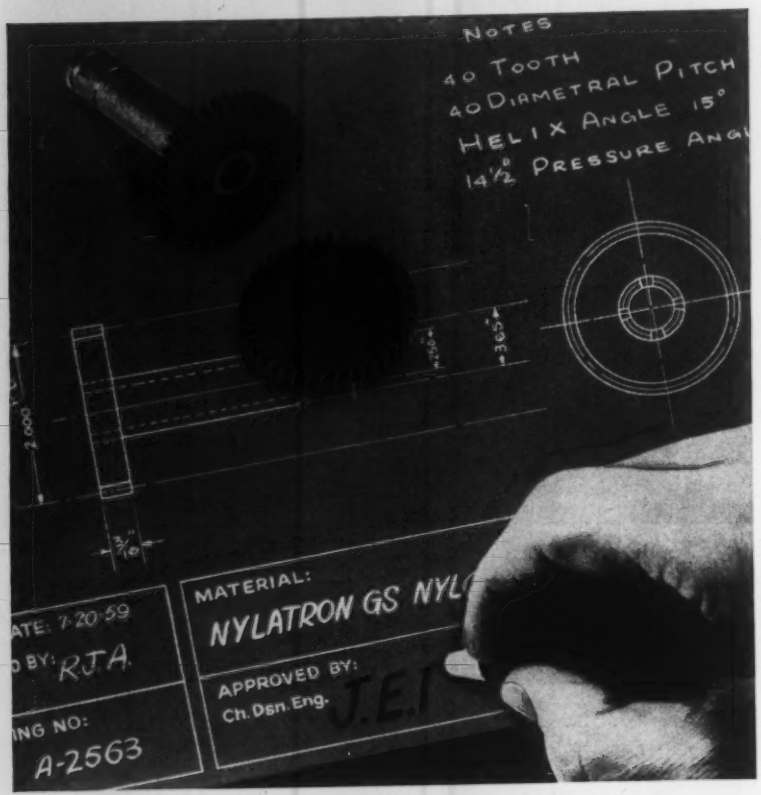
HELI-COIL CORPORATION
DANBURY, CONNECTICUT

HELI-COIL CORPORATION, 509 Shelter Rock Lane, Danbury, Connecticut
I'd like more information on *Heli-Coil* Screw-Thread Inserts
NAME _____ TITLE _____
FIRM _____
ADDRESS _____
CITY _____ ZONE _____ STATE _____ 1962

IN CANADA: W. R. WATKINS CO., Ltd., 41 Kipling Ave., S., Toronto 18, Ont.

Circle 511 on Page 19

where performance counts...



Nylatron® GS nylon

(nylon + molybdenum disulphide)* Injection Molding Compound

—specified for outstanding properties—

Compared to conventional nylon, NYLATRON GS molded parts display:

- Superior wear resistance
- Lower moisture absorption
- Exceptional dimensional stability
- Less deformation under load
- Higher heat distortion temperature
- Decreased stress—less warpage
- More rigid thin sections
- Increased tensile and flexural strength
- Properties similar to machined prototypes

Write for latest data.

NATIONAL POLYMER PRODUCTS, INC.
Reading, Pa.

A subsidiary of The Polymer Corporation, Reading, Pa.
Export: Polypenco, Inc., Reading, Penna., U.S.A.

*Composition and use covered by United States Patent No. 2,855,377.

POLYPENCO

Circle 512 on Page 19

HELPFUL LITERATURE

Valves

Bronze and iron body gate, globe, and check valves for heating, piping, and air conditioning systems are given capsule description in Folder V-6. Pressures range up to 300 psi. Threadless valves for soldered or brazed connections are also shown. 6 pages. Fairbanks Co., 393 Lafayette St., New York 3, N. Y. D

Circle 661 on Page 19

Linear Actuators

Product data supplements 102-1, 102-3, and 102-4 list variations in Series 413, 434, and 435 linear actuators. Graphs portray speed for varying loads. These field tested actuators meet general MIL requirements. 2 pages each. Lear, Inc., Electromechanical Div., 110 Ionia Ave., N.W., Grand Rapids 2, Mich. H

Circle 662 on Page 19

Servo Clamps

Full information on a line of servo and related clamps for use by the servo computer, electro-mechanical, and electronic industries is contained in Catalog 50. Dimensioned drawings aid in engineering applications. 48 pages. Sterling Precision Corp., Instrument Div., 17 Matinecock Ave., Port Washington, N. Y. D

Circle 663 on Page 19

Metal Forming & Finishing

A picture trip through the Vollrath plant is provided by Brochure 39 which shows metal forming, finishing, and foundry activities. Company produces deep-drawn, spin-formed, and cast metal products which are polished and buffed, or vitreous-enameled. 12 pages. Vollrath Co., Sheboygan, Wis. K

Circle 664 on Page 19

Fuse Equipment

All fuse requirements from 30 to 200 amps can be met with only 10 enclosures which are described in Bulletin 1-215. Five stab-in units shown and rated 30 through 100 amp are designed on modules of 1½ in. 12 pages. Federal Pacific Electric Co., Newark 1, N. J. C

Circle 665 on Page 19

Semitubular Rivets

"Dimensional Standards for Semi-Tubular Rivets" covers all major classes and includes body and head diameters, head thicknesses and radii, hole diameters, and depth figures. 4 pages. Write Tubular and Split Rivet Council, 53 Park Place, New York 7, N. Y. D

Circle 666 on Page 19

Preamplifiers

Capsule description of Tullamore preamplifiers for use with scintillation, proportional counters, or GM-tube detectors is given in mailing Form 3023-9. 2 pages. Victoreen Instrument Co., 5806 Hough Ave., Cleveland 3, Ohio. G

Circle 667 on Page 19

Clutch-Pulley Package

The Electro-Sheave clutch-pulley package for fast cycling of machine drives provides direct instant load control in one easy-to-mount unit. It combines advantages of the Warner electric clutch with a ball-bearing sheave. Complete details are furnished in illustrated brochure. 10 pages. Warner Electric Brake & Clutch Co., Beloit, Wis. K

Circle 668 on Page 19

Transmissions & Reducers

Engineering folder compiles descriptive data sheets on 15 heavy duty transmissions with maximum input torques from 120 to 1650 lb-ft. Data show reduction gear selection, capacity curves, specs, and dimensional drawings. Single and multispeed units are covered. 18 pages. Cotta Transmission Co., 2300 Eleventh St., Rockford, Ill. K

Circle 669 on Page 19

Magnesium Castings

Well illustrated Brochure 141 on sand and permanent mold magnesium castings takes reader on a quick tour of company's plant, showing facilities and the quality and intricacy of work being done in this field. Castings shown include electronic units, aircraft parts, and missile components. 16 pages. Dow Chemical Co., Midland, Mich. H

Circle 670 on Page 19

Ingot Iron Tubing

Data Memorandum No. 18 lists nominal chemical analysis, mechanical and physical properties, standard production limits, and standard tubing tolerances for ingot iron tubing. Outside diameters range from 0.012 to 0.625 in. with various wall thicknesses. Fabrication guidance is offered. 2 pages. Superior Tube Co., 1578 Germantown Ave., Norristown, Pa. E

Circle 671 on Page 19

Nickel Casting Alloys

"A Quick Guide to the Nickel-Containing Casting Alloys" gives capsule reviews of each alloy, its important properties, and suggested uses in various fields. All data are arranged for ease of use. 27 pages. International Nickel Co., 67 Wall St., New York 5, N. Y. C

Circle 672 on Page 19

Cold Extruded Parts

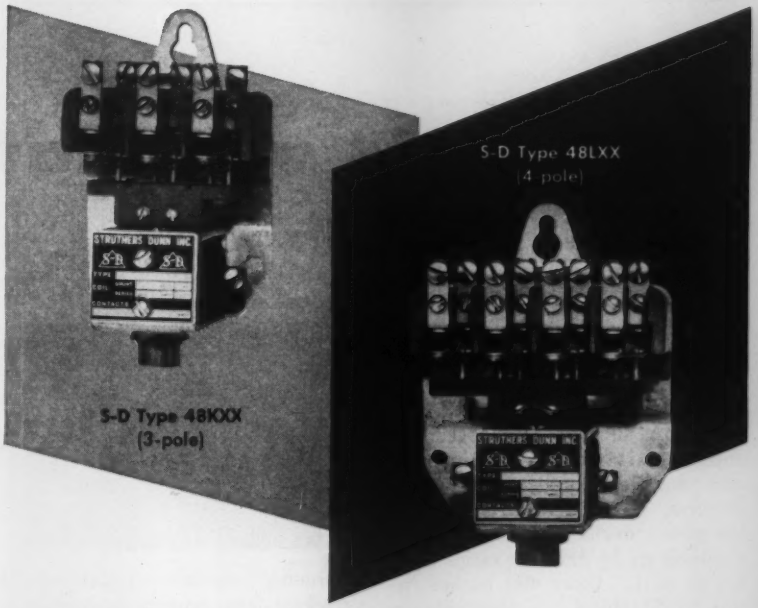
Bulletin treats the process of cold extruding metal parts. Physical characteristics, mechanical properties, economies, and applications are discussed. 4 pages. Burgess-Norton Mfg. Co., Geneva, Ill. I

Circle 673 on Page 19

Aluminum-Bronze Bars

Advantages of both solid and centrifugally-cast cored aluminum-bronze bars are outlined in folder. Bars are available in standard 12½-in. lengths and in sizes up to 8-in. OD. Data cover applications in gears, worms, valve seats, guides, and other items. 4 pages. Johnson Bronze Co., New Castle, Pa. G

Circle 674 on Page 19



Small Size . . . Long Life . . .

ECONOMY CONTACTORS

for motor control applications

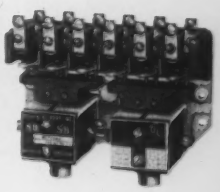
Backed by full Struthers-Dunn quality, designed to minimum size consistent with dependable performance, these new 3- and 4-pole AC contactors are ideally suited for "built-in" control of AC motors, solenoids, valves, lamps, heaters and other loads.

Contacts are conservatively rated at 15 amperes to 600 volts AC and with horsepower ratings to 3 h.p. for 440/550-volt service AC 3-phase.

Struthers-Dunn Data Bulletin 7048 will bring you full details.

REVERSING TYPE

S-D Type 175KXX includes two durable solenoids each opening three double-break, normally-open contacts. Ratings are similar to above. Write for S-D Data Bulletin 7100.



STRUTHERS-DUNN, Inc.

Pitman, N. J.

5,348 Relay Types...World's most diversified relay selection

Sales Engineering Offices in: Atlanta • Boston • Buffalo • Chicago • Cincinnati Cleveland • Dallas • Dayton • Detroit • Kansas City • Los Angeles • Montreal • New Orleans • New York • Pittsburgh • St. Louis • San Francisco • Seattle • Toronto

Circle 513 on Page 19

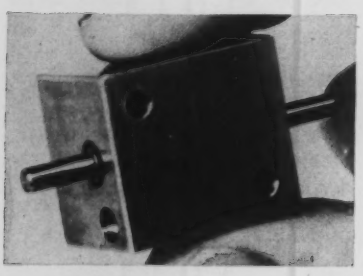
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Subminature Speed Reducers

for use in low-power devices

Series 5A subminiature speed reducers are suitable for use in business machines, indicators, timers, cameras, chart drives, and other low-power devices. Unit shown is available in 34 different ratios from 1:1 to 27:1. Over 400 higher ratios to 531,441:1 are available in longer units. They handle 16 oz-in. of torque at low-speed shaft, and speeds to 3600 rpm on high-speed shaft are reached without excessive



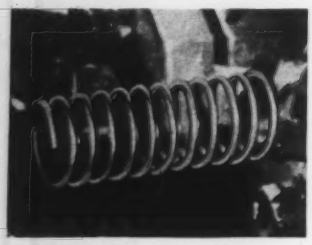
wear. Precisely hobbed, smooth-running spur gears are 96 pitch and 20-deg pressure angle types of case-hardened steel. Hardened and polished input shaft, output shaft, and countershafts run in sintered nickel-silver bearing surfaces of case itself. Gears are permanently lubricated. Units mount in any position with shaft heights at either ¼ or ½ in. **Metron Instrument Co.**, 432 Lincoln St., Denver 3, Colo. K

Circle 675 on Page 19

Spring Wire

operates at 400 to 1400-F temperatures

Alloy HS 25 or L-605 is composed principally of cobalt, 46 to 53 per cent; chromium, 19 to 21 per cent; tungsten, 14 to 16 per cent; nickel, 9 to 11 per cent; carbon, 0.05 to 0.15 per cent. The precipitation-



hardened superalloy cobalt wire is used to form springs to operate at ambient temperatures from 400 to 1400 F. Wire is available annealed to 35 per cent reduction. Wire drawn to 30 per cent reduction is available from 0.171 to 0.018 in. diam. Tensiles for the 30 per cent reduction range from 200,000 to 240,000 psi, depending on wire diameter, and elongation ranges from 4 to 8 per cent. Wire is supplied for automatic coiling with gray oxide finish that can be removed by nitric acid, tumbling, or vapor blasting. Rods are welded together with magnetic stainless steel. Since material is nonmagnetic, welds in finished springs can be identified with a magnet. **National-Standard Co.**, Niles, Mich. H

Circle 676 on Page 19

Miniature Counter

has high speed and low torque

High-speed miniature counter is suitable for many applications requiring small size and weight, low torque, and low cost. Counter is an external-pinion type, with ½-

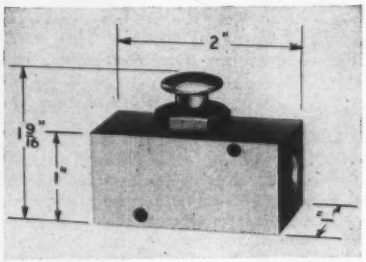
in. wheels displaying ⅛-in. white characters on black. Nonreset wheels are lightweight nylon. Maximum torque is 0.01 oz-in. at 25 C, and maximum operating speed is 1000 rpm. Complete counter weighs only ¼ oz, and meets military aircraft-instrument shock and vibration requirements. **Instrument Div., Veeder-Root Inc.**, Hartford 2, Conn. B

Circle 677 on Page 19

Palm-Button Valve

has single poppet element

Three-way palm-button valve has full ⅛ and ¼ in. orifices for pressures from zero to 200 psi. Corrosionproof valve has a single poppet element. Body is aluminum, and all other parts are brass. Measuring 2 x 1 9/16 x 1 in., valve can be mounted in any position by means



of two mounting holes. **Airmatic Valve Inc.**, 7317 Associate Ave., Cleveland 9, Ohio. G

Circle 678 on Page 19

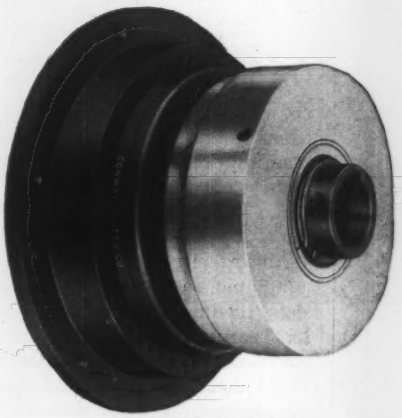
Triple-Purpose Screw

for appliances requiring grounding protection

Triple-purpose fastener, called grounding terminal screw, is designed for use with clothes dryers, built-in ranges, and other appliances requiring electrical grounding protection for the user. Enamel reaming point removes porcelain

The World's Most Respected Name in Industrial Clutches for Over a Half-Century

JUST DO THIS



STATIONAIRE

"The Original Stationary Air Housing"

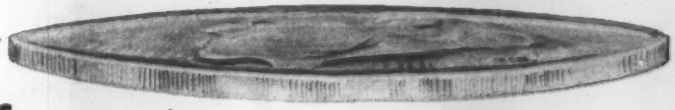
two sides to this coin

The ease of installation for the Conway Manual Clutch is a tradition. But "heads up" even this has been improved with the fabulous STATIONAIRE by Conway.

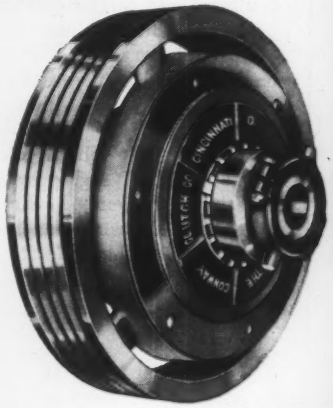
here's why

Complete installation of STATIONAIRE requires *but 4 extremely simple, labor-saving steps* . . . practically no work at all:

1. Attach to unit to be driven.
2. Slide clutch onto shaft.
3. Tighten set screw.
4. Hook up air line.



YOU DON'T DO THIS



Save on these extra steps needed to install manually controlled clutches (as on our P25-A easy to install):

1. Line up yoke.
2. Drill holes for fulcrum.
3. Mount fulcrum.
4. Mount yoke on shifter mechanism.
5. Connect yoke to fulcrum.

Whether heads or tails, Conway does it better, faster and with tremendous savings.

WRITE FOR CATALOGS

The CONWAY CLUTCH COMPANY

2750 COLERAIN AVE. CINCINNATI 25, OHIO

Where the temperature hits 200°C ... or drops to −65° ... where a dry circuit is downright arid ... or a power circuit employs 10 amperes (or even 20 amps for a short life need) ... your best bet for reliability is a "Diamond H" Series R miniature, hermetically sealed, aircraft type relay. Their shock and vibration resistance you may take for granted.

Variations on the basic 4 PDT Series R relay perform outstandingly over such a broad area that they are frequently used to do many different types of jobs in a given application, with resultant savings in spare part inventories. The range of possible characteristics covers:

Various brackets of vibration resistance from 10 to 2,000 cps, coil resistances from 1 to 50,000 ohms, operational shock resistances of 30, 40, or over 50 "G"; mechanical shock resistance to 1,000 "G", contact capacities from 350 V., D.C., 400 MA, to 10 A., at 30 V., D.C., as well as signal circuits.

For complete information send for a copy of Bulletin R-250.

THE HART MANUFACTURING COMPANY
118 Bartholomew Avenue, Hartford, Conn.

Circle 515 on Page 19

New DuPont Thermoplastic with Metal-Like Qualities Makes POSSIBLE NEW TINY COMPONENT APPLICATIONS Thru GRC ENGINEERED Precision MOLDINGS

DuPont's new acetal resin, DELRIN, with mechanical properties equalling metals in many ways—while excelling in corrosion-resistance, resilience, non-conductivity, and other important factors, is NOW available from Gries in tiny parts engineered to precision tolerances.

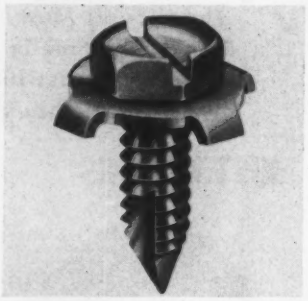
Successful techniques for production-line molding of DELRIN have been developed by GRC, the result of our two years' pioneering—and another industry dividend deriving from GRC's long experience in injection molding thermoplastics to exacting specifications. The reliability of Gries procedure for DELRIN fabrication is proved by long production runs on parts like those shown here.

For other service requirements, let Gries' experience in injection molding of Nylon, Cycolac, Kel F, and other Engineered thermoplastics solve your problems on tiny parts with precision specs. Send prints for quotation—quantity from 25,000 to millions. Maximum size .03 oz—1¼ long. No size too small.

Write today for DELRIN data and Literature on GRC Automatic Molding Services.

GRIES

GRIES REPRODUCER CORP.
World's Foremost Producer of Small Die Castings
32 Second St., New Rochelle, N. Y. • NEw Rochelle 3-8600



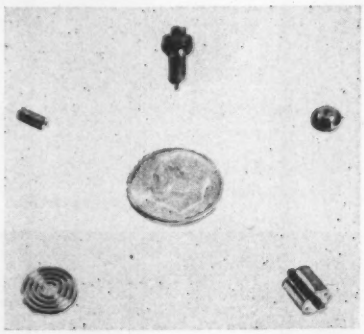
enamel, paint, or other finishes from hole, eliminating separate reaming operation. Thread-cutting feature cuts threads deep into bare metal of panel, assuring positive metal-to-metal connection. Preassembled tab washer, with legs adaptable to various ground wire sizes, retains wire loop firmly under its bearing surface for maximum electrical conductivity. Screw is No. 10-24 size, $\frac{5}{8}$ in. long, and made of heat-treated steel. **Shakeproof Div., Illinois Tool Works,** St. Charles Road, Elgin, Ill. J

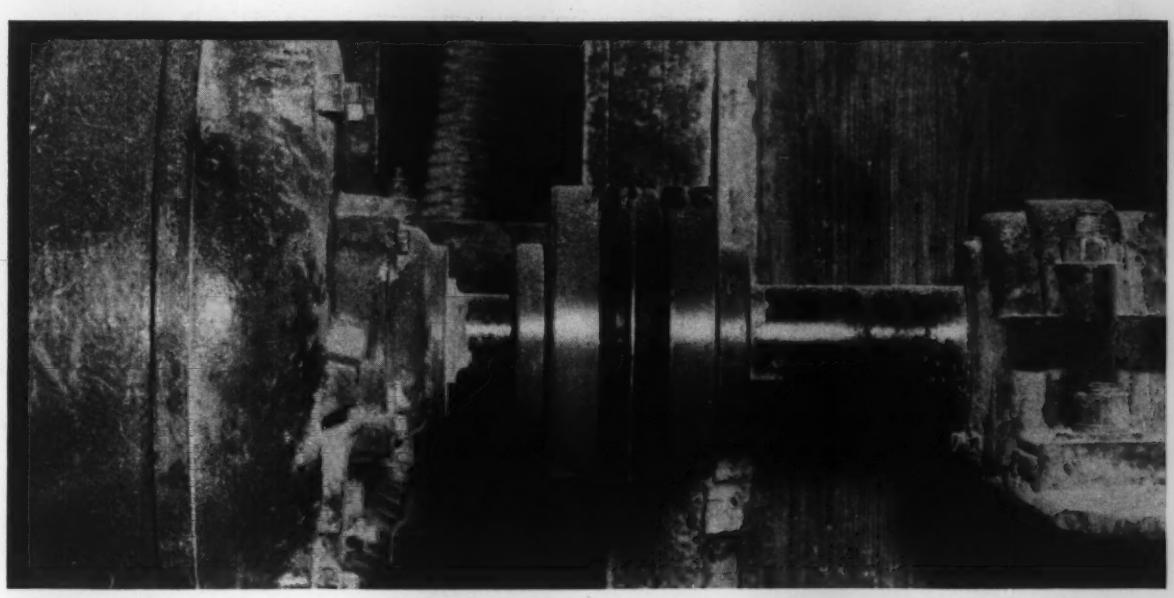
Circle 679 on Page 19

Bellows and Seals

are miniaturized units

Thin bellows assemblies, designated Mech-Metal, and true hermetic axial/rotary seals, Mech-Seals, are designed primarily for gyro, stable plastform, and inertial-guidance applications. Bellows assemblies are also used in cryogenics because of excellent low-temperature properties. Thin walls, high tensile strength, and high convolution density per unit length make bellows economical and provide high operating efficiency. Range of spring rates can be furnished around a given basic design. Basic metal, an alloy of nickel, is highly





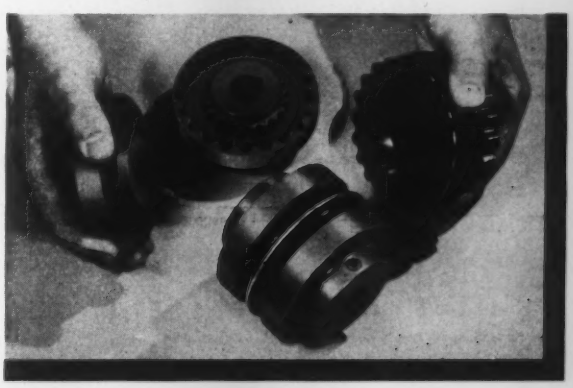
"Sure-Flex" Coupling's 4-way flex and unique design . . .

ELIMINATE MOTOR VIBRATION – FAILURE, SOLVE "IMPOSSIBLE" DRIVE PROBLEMS

Extreme vibration and shock, as well as misalignment, posed "impossible-to-solve" coupling problems with this hammer mill drive installation. The motor required rewinding twice in two years. Finally, it was necessary to shut down the mill after less than an hour of operation to let motor and machine bearings cool. A stock "Sure-Flex" Coupling eliminated the vibration . . . absorbed the shock and misalignment . . . permitted coupling of shafts having 9/16-inch diameter differential. Motor and mill bearings now run cool, regardless of operating cycle length.

Unique design and 4-way flexing action enable Wood's "Sure-Flex" Couplings not only to absorb all types and combinations of angular and parallel misalignment and end-float, but from 5 to 15 times more shock and vibration than other leading flexible couplings. There is no metal-to-metal contact, no wear, no need for lubrication or maintenance. "Sure-Flex" Couplings are unaffected by abrasives, dirt or moisture. Operation is noiseless. "Sure-Flex" gives you more for your money than any other flexible coupling. Get all of the facts. Write for Bulletin 10,100A.

SIMPLE, EASY TO INSTALL—There are only four basic parts which lock together without clamps or screws, tightening securely under torque to provide smooth, dependable power transmission.



Wood's

T. B. WOOD'S SONS COMPANY
CHAMBERSBURG, PENNSYLVANIA

ATLANTA · CAMBRIDGE · CHICAGO · CLEVELAND · DALLAS

HIGH... Production Techniques
...are Vital...
Allis-Chalmers Mfg. Co. manufactures seven models of rubber-tired front end loaders for nearly every material moving operation.
In order to meet sales commitments on the Tractoloaders, high production techniques are necessary.
HEIM
Unibal®
SPHERICAL
BEARING
ROD ENDS

Meet high production requirements because of their multiple functions and their ease of installation.

Tractoloaders provide a range of capacity from 15 cubic feet to 5 cubic yards. One of the firm's innovations includes a quick-shift transmission, as well as the first successful torque converter.

Heim Unibal Rod Ends are used in the transmission controls. A female type with built-in grease fitting is attached to the housing with a bolt and lock washer and provides the required degree of misalignment correction. Note that this application illustrates the use of the Unibal Rod End as a fixed support, rather than as a linkage terminal.

Unibal Spherical Bearings.....

- **Carry heavier loads**
- **Correct misalignment in all directions**
- **Are easy to assemble, low in cost**
- **Reduce friction and lost motion in linkages**

The Heim Engineering Department is ready with suggestions to help solve design problems requiring high-capacity, self-aligning bearings and rod ends, particularly in mechanical linkages.

PLEASE WRITE FOR COMPLETE CATALOG OR ENGINEERING ADVICE.

THE HEIM COMPANY

FAIRFIELD, CONNECTICUT

corrosion resistant. Wall thicknesses range from less than 0.0003 to over 0.003 in. Standard cylindrical, capsule, diaphragm, torus, kidney, cone, and multishaped bourdon-tube bellows assemblies are available. Temperature range is −320 to +300 F. Miniaturized hermetic axial/rotary seals utilize bellows assemblies and are furnished in three basic models: Rotary-shaft; rotary-axial; axial shaft. **Mechmetal-Tronics,** 11431 Joanne Place, Culver City, Calif. L

Circle 680 on Page 19

Miniature Brakes

for small motors and gear trains

Miniature electromagnetic brakes are available for mounting directly to small motors and gear-train housings. Brakes are available in three sizes from 1 to 2 in. OD with brake torque from 10 oz-in. to 15 lb-in.

and low power consumption of 2 to 4 w. They can be supplied to brake either when electrically energized or de-energized, and coils are available for 6, 12, 28, 48, and 100 v dc. Brakes meet all applicable military specifications covering shock, vibration, temperature, and humidity. **Dial Products Co.,** 19 Cottage St., Bayonne, N. J. D

Circle 681 on Page 19

Readout Photocells

have extremely fast response time

Designed specifically for computer and data - processing equipment where rapid detection of light passing through punched cards or tape is required, silicon photovoltaic readout matrices feature fast response time of about 10 mu sec.

EMCOR®*

CABINETS HOUSE THE NERVE CENTER OF A MODERN MECHANIZED ORACLE

Your copy of Catalog 106, Condensed Version, Available upon Request

Research personnel of Bell Telephone Laboratories, New York, get an "insight" into customer desires and response to new telephone services through "Sibyl," a computer-like machine and laboratory housed in EMCOR Cabinets. "Sibyl" simulates a variety of future communication devices and systems providing objective data on telephone users' response to new service. From the data collected, Bell Laboratories' engineers and psychologists hope to predict whether a new facility will be useful and attractive from a customer's viewpoint. The use of this unusual laboratory eliminates the expense of building special test equipment for one-time use. The use of EMCOR Modular Enclosures in housing the nerve center of the "Sibyl" test facility present a compact, centralized and inter-connected control center. Human engineering features of the modular cabinet design bring all equipment within easy reach and sight of the operator.

QUALITY® EMCOR PRODUCTS

Originators of the Modular Enclosure System

ELGIN METALFORMERS CORP.

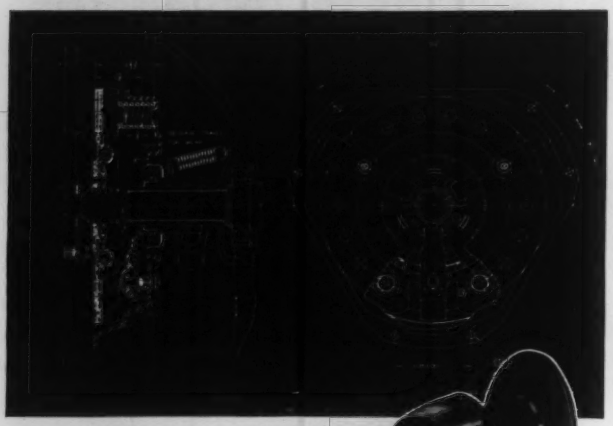
630 CONGDON, DEPT. 1226 • ELGIN, ILLINOIS

*Registered Trademark of Elgin Metalformers Corporation

VISIT OUR I.S.A. SHOW BOOTH 474, SEPTEMBER 21st—25th, AMPHITHEATRE, CHICAGO, ILLINOIS

Circle 519 on Page 19

ROCKFORD



Design and Stay With the Genuine

ROCKFORD CLUTCHES provide the advantages of heat-treated, hardened and ground steels—flat, non-grab facings—heat dissipation—dirt exclusion—and fine adjustments. Only ROCKFORD provides clutch levers that reduce friction, improve release action and prevent lever throw-out. These wear-resisting, life-lengthening clutch features are essential to designs that must be projected with a thought to uses of tomorrow. ROCKFORD engineers now are working with many companies on their future designs—to provide custom-engineered clutches for long range economy. Their services are available to you.

See us in Booths No. S-1 to S-16 at the Milwaukee S.A.E. Convention

SEND FOR THIS HANDY BULLETIN

Shows typical installations of ROCKFORD CLUTCHES and POWER TAKE-OFFS. Contains diagrams of unique applications. Furnishes capacity tables, dimensions and complete specifications.

ROCKFORD Clutch Division BORG-WARNER

311 Catherine St., Rockford, Ill., U.S.A.

Export Sales Borg-Warner International — 36 So. Wabash, Chicago 3, Ill.

Small Spring Loaded

Automotive Spring Loaded

Heavy Duty Spring Loaded

Oil or Dry Multiple Disc

Heavy Duty Over Center

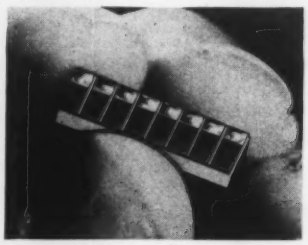
Light Over Center

Power Take-Offs

Speed Reducers

ROCKFORD B-W BORG-WARNER

CLUTCHES



Self-generating devices convert light energy directly into electricity, with no need for external power supplies. Each matrix is made up of an array of individually segmented silicon cells. Light energy striking a particular segment causes power to flow from that segment only. Typical current generated is 300 mu amp for 0.01 sq in. of active cell area at 1000 ft-c illumination. Units are supplied in single or multiple-cell assemblies. **International Rectifier Corp.**, 1521 E. Grand Ave., El Segundo, Calif. L

Circle 682 on Page 19

Rolling Diaphragm Seal

operates in temperatures to 550 F

Long-stroke rolling diaphragm seal for aircraft, missiles, rockets, and other control and regulator applications is extremely thin-walled, offering maximum stroke, flexing life, and sensitivity. It operates in temperatures to 550 F. Seal is available in a wide range of elastomers that can be combined with a glass-fabric overlay for maximum temperature protection over a wide range of physical and chemical requirements. Narrow - convolution design of high-temperature seal permits use of exceptionally high working pressures in seal designs, since only a small fraction of applied pressure is experienced as fabric stress. Standard sizes are available in 1 to 6-in. diam with

maximum stroke to 4 in. Four different classes of mounting configurations are available for installation. **Bellofram Corp.**, Blanchard Rd., Burlington, Mass. B

Circle 683 on Page 19

Speed Reducers

in new 25:1 series

Torque-Arm shaft-mounted speed reducers have output speeds from

12 to 400 rpm. Line includes new 25:1 double-reduction series in eight sizes. Largest unit is Size TD11, with reduction ratio of 24.73:1. It is rated 154 hp at 75 rpm, the maximum recommended output speed for this size. New method of attaching torque arm to reducer case permits improved design without changing over-all dimensions or horsepower ratings. **Dodge Mfg. Corp.**, Mishawaka, Ind. J

Circle 684 on Page 19

Germanium Tetrodes

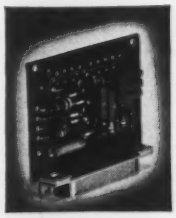
attain maximum gain at low power levels

No. 3N36 and 3N37 germanium tetrode transistors are available for industrial and military applications such as wide-band RF amplifiers, radar IF amplifiers, and high-frequency mixers and oscillators. The 3N36 has an operating range of 30 to 100 megacycles and the 3N37 from 100 to 300 megacycles. Both transistors attain maximum gain at power levels as low as 5 mw. Tetrodes are extremely rugged, achieved by the use of encapsulation techniques which allow them to withstand a 3-ft drop shock test, and have stability of gain with change of ambient temperature. Cases are

Now! A higher reliability factor in printed circuits

ALTORI

a new and distinctively different finish on TAYLOR copper-clad laminates that accepts all acid resists uniformly



Something new and distinctively different has been added to TAYLOR copper-clad laminates — a finish that accepts all types of acid resists uniformly. High fidelity in printed circuit reproduction is assured. Circuits can be of consistently higher quality and reliability, no matter how critical the design. For complete details about TAYLOR copper-clad laminates and samples, write TAYLOR FIBRE CO., Norristown 47, Pa.

Taylor

LAMINATED PLASTICS VULCANIZED FIBRE

Circle 521 on Page 19

NEW 2¼ HP ANGLgear® HELPS SIMPLIFY YOUR 90° DRIVE PROBLEMS

Hardened bevel gears and antifriction bearings insure smooth, trouble-free operation. Completely enclosed, permanently lubricated ANGLgear requires little or no maintenance.

Addition of the new 2¼ hp size to the ANGLgear line makes it easier than ever to solve your 90° power takeoff problems with this standardized right-angle drive. You can now specify ANGLgear in any one of 16 different stock models, offering power ratings from ⅛ to 5 hp, with choice of 1:1 or 2:1 gearing and 2 or 3-way shafting.

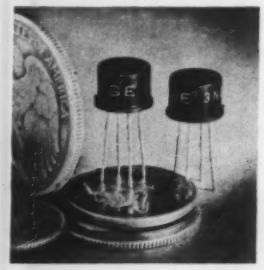
Compact, high capacity ANGLgear offers you several distinct advantages over V-belts or chains and sprockets. Featuring 5-way mounting, it is easier to design into your power transmission systems. Incorporating positive bevel gear drive, it eliminates slippage and backlash problems. Completely enclosed, it presents no safety hazards. Permanently lubricated, it requires virtually no maintenance. And not the least important, ANGLgear invariably costs less than other types of 90° drives.

See our literature in Sweet's Product Design File or contact your local distributor.

AIRBORNE®

AIRBORNE ACCESSORIES CORPORATION
HILLSIDE 5, NEW JERSEY

Circle 522 on Page 19



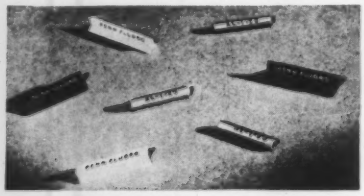
suitable for insertion into printed boards by automatic assembly equipment. **Semiconductor Products Dept., General Electric Co.,** Liverpool, N. Y. N

Circle 685 on Page 19

Teflon Tubing

has indelible printing for easy identification

Spaghetti, flexible, instrument, and heavy-walled tubing of Teflon is indelibly printed with numbers for identification to meet individual requirements for aviation, electronic, electrical, chemical, food, petroleum, and general industrial applications. Numbers will not fade, chip, or peel off, and tubing has complete chemical inertness, excellent electrical properties, low coefficient of friction, low permeability, and service temperature range of −450 to +500 F. Indelibly printed flexible tubing is available in ⅛ to 1⅛-in.



ID sizes, spaghetti tubing in sizes from zero to AWG No. 32, instrument tubing from 0.01 through 1 in. ID, and heavy-walled tubing in standard commercial sizes. **Pennsylvania Fluorocarbon Co. Inc.,** 1115 N. 38th St., Philadelphia 4, Pa. E

Circle 686 on Page 19

Revolving Handles

for use on handwheels

Revolving aluminum handles that attach to handwheels to simplify turning feature a long bearing surface to eliminate much turning fric-

MOLDED FIBER GLASS makes the revolutionary new White "5000" Cab

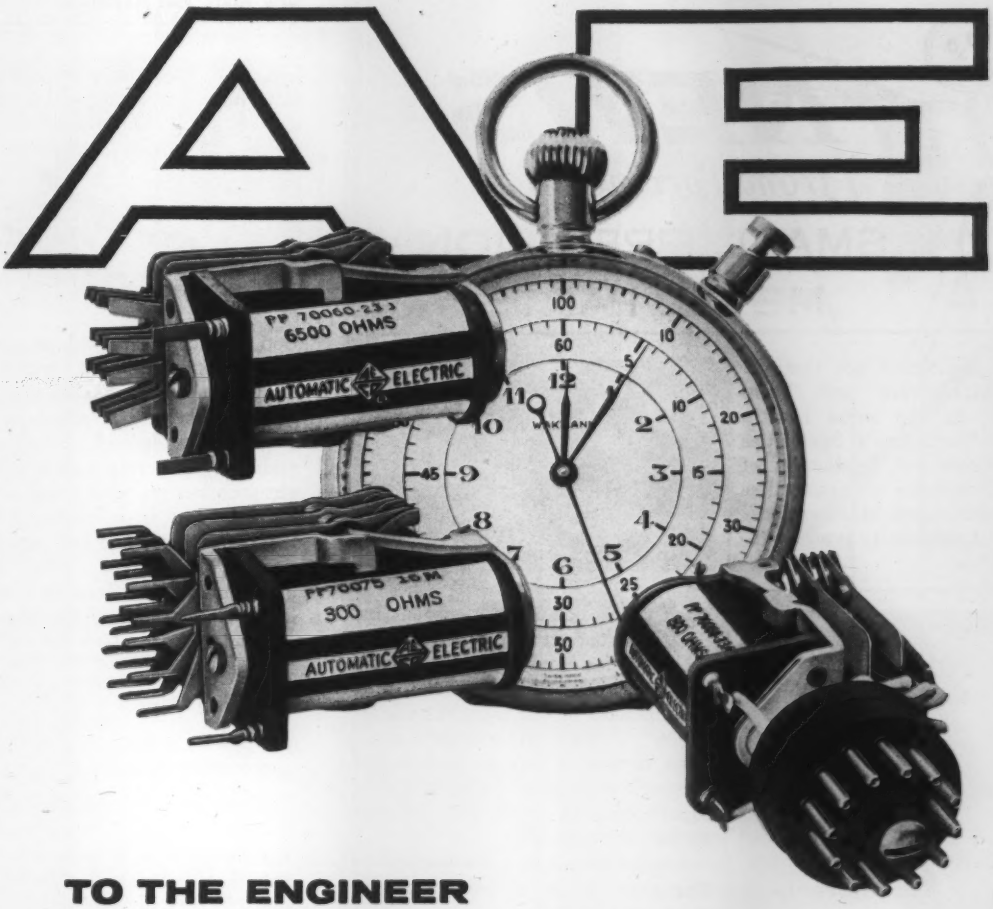
It's a radical new design, possible only with MOLDED FIBER GLASS . . . it is thirty-six MOLDED FIBER GLASS parts, bonded into an integral unit . . . space saving, efficient, lightweight, profit-earning.

This MOLDED FIBER GLASS cab is warm in winter, cool in summer, quiet . . . rust-proof, impervious to salt and road chemicals . . . tough, impact-resistant.

Write or phone today for cost estimates on making *your* products better with MOLDED FIBER GLASS, as matched-metal-die-molded by the world's largest, most experienced producers of fiberglass reinforced plastic.

Molded Fiber Glass Body Company

4629 Benefit Avenue, Ashtabula, Ohio



TO THE ENGINEER

looking for a quick connection

Engineers out to cut costs at no expense of reliability can count on dramatic savings in assembly and wiring time by designing around AE Class E relays with quick-connect terminals.

Series EQPC is designed for direct insertion into printed circuits. Series EQTT, with Taper-Tab terminals, provides firm, high-conductivity connections without soldering.

AE also supplies Class E relays prewired for plug-in – with standard 8- to 20-prong octal plugs. Where additional relay protection is essential, the plug-in types are available in hermetically sealed containers or with dust-tight housings and hold-down brackets.

The AE Class E relay is a miniaturized version of the premium-quality Class B, with many of its best features. Perfect contact reliability exceeding 200 million operations is common.

AE is also equipped to supply wired and assembled, custom-built control units, *or to help you develop complete systems.*

Want details? Just write the Director, Control Equipment Sales, Automatic Electric, Northlake, Illinois. Also ask for Circular 1702-E on *Relays for Industry*, and the new 32-page booklet on *Basic Circuits.*

AE CAN DO

AUTOMATIC ELECTRIC GENERAL TELEPHONE SYSTEM

Subsidiary of

GENERAL TELEPHONE & ELECTRONICS

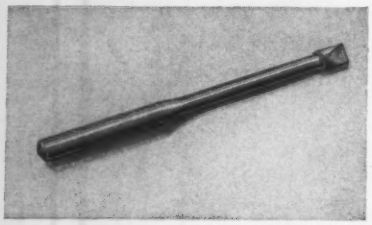
Circle 523 on Page 19

NEWS
from Torrington on
SMALL PRECISION METAL PARTS

Ordinarily, one would not think of "custom manufacture" and "mass production" in the same breath. Except at Torrington's Specialties Division, where the production of tremendous varieties and quantities of small metal parts of exceptional precision and uniformity is a day-to-day occurrence.

A good example is the valve stem we make for a leading pump manufacturer. Operations include turning, threading, slotting and tempering. Nothing unusual about that, except that Torrington can do it to such precision that the specified finish of 4 to 6 micro-inches is achieved without grinding. This saves our time—and our customer's money, yet every part is produced to perfection.

Another interesting case is an insulated contact pin. It is driven into



wood to check moisture content by electrical conductivity. The reduced center section is insulated. The shank must be accurate to ±.0005", and the diameter of the tapered neck to +.005", −.000". Torrington's engineers devised a way to back-swage the neck to required taper and trim square between head and reduced section *automatically*.

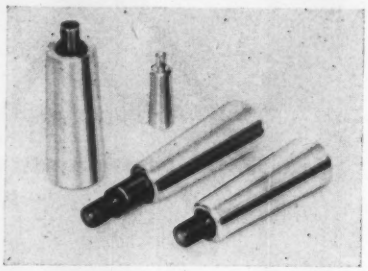
The manufacture of such parts as these, in the tremendous quantities required of us every day, demands highly specialized engineering skills. To serve you most efficiently, our Specialties Division maintains a separate engineering department. Staffed with engineers who have wide experience in precision metalworking, the department can help you with any engineering problems that might arise

in the manufacture of your special metal parts. For prompt service, just circle our number on the reply card, call our area salesman or write direct to:

The Torrington Company, Specialties Division, 626 Field Street, Torrington, Conn.

TORRINGTON SPECIAL METAL PARTS

Makers of Torrington Needle Bearings



tion, reduce wear, and provide additional strength. As handwheel is turned, revolving handle grip spins on a steel stud attached at right angles to handwheel. Handle is attached by inserting stud at convenient location on wheel and slipping handle grip over stud. Locking ring assures positive fit. Lengths of various handles are 1 9/16, 2, 2½, 2⅞, and 3¼ in. **Jergens Tool Specialty Co.**, Cleveland 10, Ohio. F

Circle 687 on Page 19

Precision Pins

are 2-in. long, reversible units

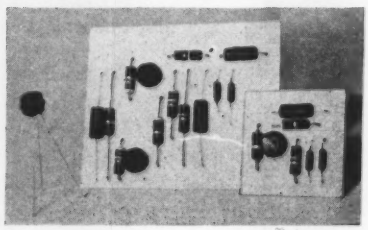
De-Luxe line of precision pins includes sizes from 0.03 to 0.75 in. in increments of 0.001 in. with guaranteed tolerance of ±0.00005 in. Construction of the 2-in. long pins enables user to reverse pin when worn, providing longer life and continuous accuracy. **Dundick Tool Works Inc.**, 3410 W. 31st St., Chicago 23, Ill. J

Circle 688 on Page 19

Semiconductor Component

has flip-flop characteristics

New semiconductor component which performs function of a partial or complete electronic circuit is the Trigistor. It has characteristics comparable to a flip-flop or bistable multivibrator. Trigistor is a silicon PNPN device with property of



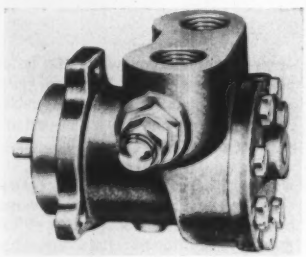
triggered turn-off and triggered turn-on control at its base. It turns on with application of a low-level positive pulse to its base. It remains on without need for sustaining base current, and negative pulse to base turns it off. Unit is designed for operation in the range of 1 to 8 ma collector current. It is particularly useful for memory, counting, timing, gating, and logic functions, and operates in temperatures from −65 to +125 C. Single Trigistor usually performs same function as two transistors plus several associated capacitors and resistors. Photo compares standard flip-flop unit (left) with Trigistor (right). **Solid State Products Inc.**, One Pingree St., Salem, Mass. B

Circle 689 on Page 19

Rotary Pump

has spring-loaded, single-lip seal

Model LA pump can be used in a variety of hydraulic, fuel-oil, and lubricating applications. It incorporates a spring-loaded, single-lip



seal which provides greatest possible protection against leakage. Pump is furnished in six different sizes with capacities to 6 gpm, for pressures to 500 psi, at 3600 rpm. **Tuthill Pump Co.**, 953 E. 95th St., Chicago, Ill. J

Circle 690 on Page 19

V-Belt Drives

use fewer belts, small sheaves

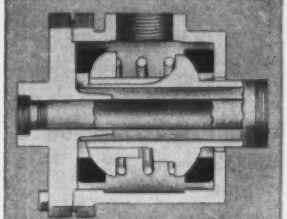
Compact V-belt drives, called 3-5-8, utilize improved V-belts with cross-sectional areas reduced nearly 50 per cent with no loss in life expectancy. Up to three times as much power can be transmitted in the same area, or fewer belts, narrower sheaves, and much smaller center

You can depend on

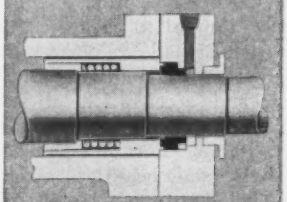
PY4

Morganite

SEALS



PY4 seal rings operate with highest efficiency in this rotary pressure joint carrying steam-condensate.



Mechanical seals with Morganite PY4 noses provide an extra measure of dependability in this stuffing box assembly.

Application tested for all sealing requirements

Service-proven on toughest assignments

LINK PY4 GRADE of self-lubricating MORGANITE is the engineer-preferred seal material for every application where premium performance is a "must." Actual service records compiled on PY4 Seals in all types of rigorous service, prove that this super-rugged material can take punishment! PY4 Seals function with highest efficiency in the presence of grease, searching liquids, corrosives, high pressures and high temperature. Install Morganite LINK PY4 for longer seal life . . . reduce down-time and save on seal replacement costs.

AVAILABLE WORLDWIDE—Send drawings and operating data for a recommendation on your specific seal requirements.

FOR OVER HALF A CENTURY...

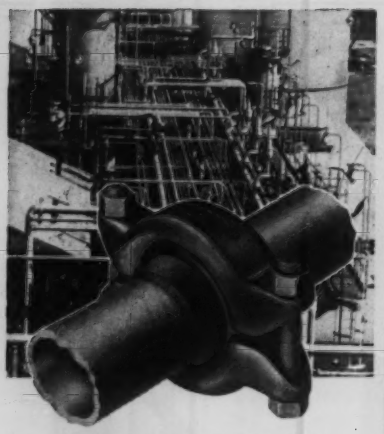
Morganite INCORPORATED

3314 48th Avenue, Long Island City 1, New York

In Canada: Morganite Carbon Products Ltd., Toronto

Manufacturers of Fine Carbon Graphite Products including Mechanical Carbons, Motor and Generator Brushes, Carbon Piles, Current Collectors and Electrical Contacts... Distributors of 99.7% Pure Al_2O_3 Tubes and Crucibles

Circle 525 on Page 19



GRAYLOC
New Principle of Pipe Connections

Two-bolt GRAYLOC Pipe Connections introduce a new principle in pipe make-up. Its design makes it possible for GRAYLOC to withstand full vacuum, high external pressure and extreme internal pressure. Moreover, this design makes it possible to make up GRAYLOC Connections repeatedly with no wear or other damage to the connections.

The bolting carries no primary force from internal pressures. Two bolts serve only to pull the connection together through the wedging action of the clamp and the seal ring.

Flexible tapered lips of the seal ring are angled slightly less than the mating hub. This forms a line seal which is changed to a surface seal as the connection comes together and the lips deflect.

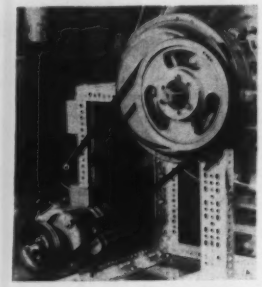
GRAYLOC has practical uses in any application where flanges are used. GRAYLOC is recommended where pressures are high or where you want savings in money, space, weight or time.

For additional information, write, wire or telephone Gray Tool Company.

GRAY
Tool Company

P. O. BOX 2291 HOUSTON, TEXAS
REpublic 4-1641 5903

Circle 526 on Page 19



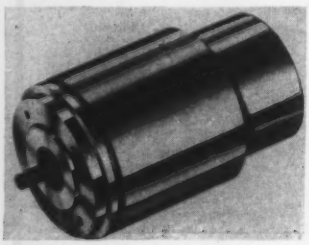
distances can be used to transmit same amount of power. Three cross-section sizes replace five sizes needed with previous V-belt drives. Each belt cross-section has been fitted to a particular horsepower range: 3-V belts (3/8-in. top width) handle drives from 1 to 50 hp; 5-V belts (5/8-in. top width) handle drives up to 200 hp; and 8-V belts (1-in. top width) transmit up to 1500 hp. Compact sheaves are equipped with quick-disconnect split bushings precisely tapered to mate with taper of sheave hub. Tight, wobblefree design permits rim speeds to 6000 fpm. **American Pulley Co.**, 4200 Wissahickon Ave., Philadelphia 29, Pa. E

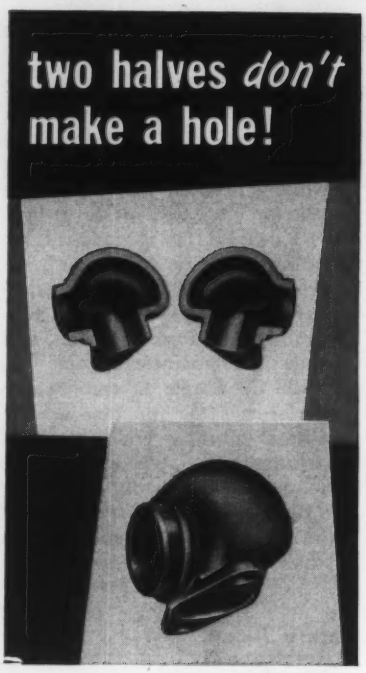
Circle 691 on Page 19

Inertia-Damped Servomotor

delivers 2.35 oz-in. stall torque

Size 18 inertia-damped servomotor is only 2.525 in. long and provides an upper-corner frequency of 27 cps. Designed for systems requiring additional stability without reduction of steady-state velocity, Model 18 IM 460 operates from a 115-v, 400-cycle source to deliver 2.35 oz-in. torque at stall. No-load speed is 4700 rpm, rotor inertia is 7.5 gm-cm^2, and acceleration at stall is 22,200 rad per sec per sec. Unit weighs 18 oz, has stainless-steel case, shaft, and bearings, and is completely encapsulated for en-





. . . *with* INVESTMENT CASTING *it's made in one piece.*

We don't tackle casting problems halfway at Hitchiner.

Here's a cross section where the inside dimensions are greater than the holes. Originally made in sections and assembled — now the whole unit is precision cast and is lighter and stronger.

Where application requirements demand that a part be of intricate shape; of unusual contour, of fine detail, or of metals difficult or impossible to machine — investment casting provides an efficient and economical solution.

Only your production costs are cut in half when you utilize the efficiency of investment casting. You save time and plenty of labor. And . . . you'll have a wide selection of metals; the non-ferrous group, the carbon and low alloy steels, the hard-to-form, hard to machine high alloy steels . . . even cobalt base alloys.

For complete details, see this new illustrated, informative booklet on the art of Investment Casting. It could be the best investment you ever made.

HITCHINER
MANUFACTURING COMPANY, INC.
MILFORD 46, NEW HAMPSHIRE

Representatives in Principal Cities

Circle 527 on Page 19

Another Tinnerman Original...

Cost-cutting Tubular **SPEED CLIP®** takes positive "bite" to hold assemblies tight!

In seconds, you can front-mount trim, name plates, grilles, knobs, insulation, with Tubular SPEED CLIPS. And at interesting savings in assembly time and costs!

Snap these quality spring-steel fasteners into holes in metal, plastic or wood. Then press the mounting studs, nails or rivets into the clips to complete the attachments... anywhere along your assembly line.

As the SPEED CLIP is inserted, spring fingers compress, then expand behind the panel to lock tight. The rolled-in end permits easy entrance, but bites hard into the stud to prevent back-off or vibration-loosening.

Tubular SPEED CLIPS are available for a full range of stud sizes and panel thicknesses. Permanent lock or removable types.

Check your Sweet's Product Design File (Section 8/Ti) for data on Tubular SPEED CLIPS and other SPEED NUT brand fasteners. Then call your Tinnerman representative for samples and additional information. If he isn't listed under "Fasteners" in your Yellow Pages, write to:

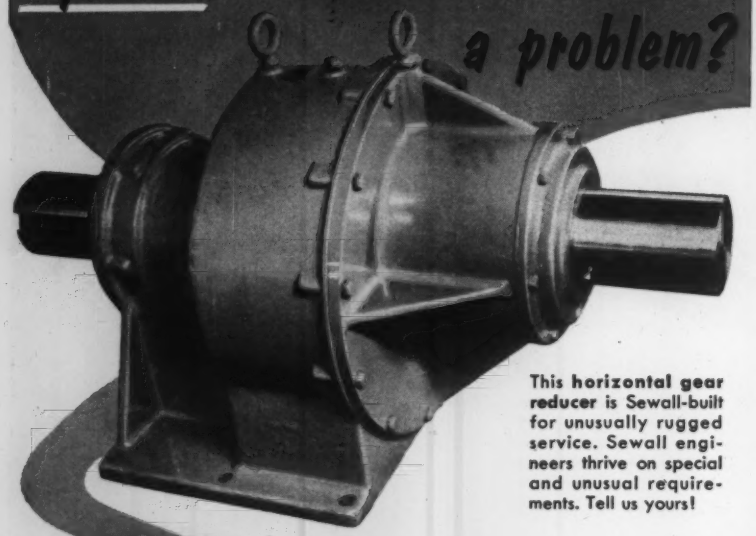
TINNERMAN PRODUCTS, INC.
Dept. 12 • P. O. Box 6688 • Cleveland 1, Ohio

TINNERMAN
Speed Nuts®

FASTEST THING IN FASTENINGS®

CANADA: Dominion Fasteners Ltd., Hamilton, Ontario. GREAT BRITAIN: Simmonds Aerocessories Ltd., Treforest, Wales. FRANCE: Simmonds S. A., 3 rue Salomon de Rothschild, Suresnes (Seine). GERMANY: Mecano-Bundy GmbH, Heidelberg.

Special GEAR BOXES a problem?



This horizontal gear reducer is Sewall-built for unusually rugged service. Sewall engineers thrive on special and unusual requirements. Tell us yours!

Announcing!

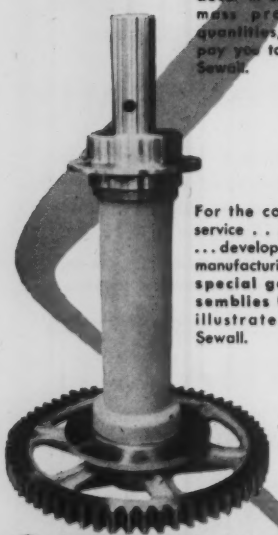
A new Sewall Service . . . designing, development and manufacturing . . . to help solve your special gear box problems . . . effectively . . . economically. We're ready to work with you at any stage of your project's development.

From scratch . . . our gear box designers will go to work for you right now. Give us a rough outline of your idea. We're staffed and equipped to design and manufacture gear boxes whatever the size and description of your requirements.

To your specifications . . . let us submit our quotation on producing your order in strict accordance with your prints. Sewall gear boxes are made by men who are fussy about specifications. Your order must be delivered as scheduled . . . priced right. Let us hear from you!

Sewall's complete gear service can help you . . . custom made gears . . . made-to-order sprockets . . . special gear racks—to order . . . standard gear racks in stock.

Whether you need gear boxes such as this worm gear reducer in custom or mass produced quantities, it will pay you to talk to Sewall.



For the complete service . . . design . . . development . . . manufacturing . . . on special gear assemblies (sample illustrated) call Sewall.

SEWALL GEARS

E. B. SEWALL MANUFACTURING COMPANY

705 Raymond Avenue, Dept. A, ST. PAUL 14, MINNESOTA, Midway 5-7721

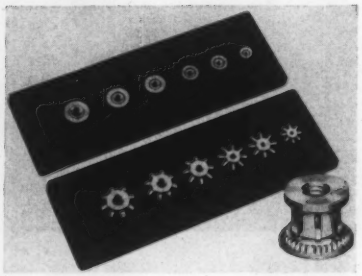
vironmental protection. It withstands 20 g vibration to 500 cps, 200 C total unit temperatures, and meets humidity requirements of MIL-E-5272A. **Helipot Div., Beckman Instruments Inc.**, 2500 Fullerton Rd., Fullerton, Calif. L

Circle 692 on Page 19

Blind Fastener

for use in sandwich panels

Series 293 blind clinch fastener is designed primarily for sandwich panels which employ fibrous skins or cover sheets such as plywood, where tensile strength of cover material is low. Two-piece fastener is installed in one side of sandwich panel and does not affect or disfigure opposite-panel cover sheet. Fas-



tener can be used for a wide range of panel thicknesses. It is available either with or without self-locking feature incorporated in internal steel threads. Materials are carbon steel and stainless steel. **Delron Co. Inc.**, 5224 Southern Ave., South Gate, Calif. L

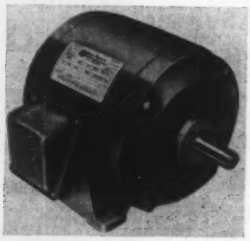
Circle 693 on Page 19

AC Motors

have low-inertia, fast-accelerating rotor

Integral-horsepower ac motors, designated Duty Master, are available in sizes from 1 to 250 hp in protected (open), weatherproof, totally enclosed, corrosionproof, and explosionproof enclosures. Motors can be specified in all standard speeds and voltages. Designs include polyphase, ball bearing, vertical, and horizontal mounting arrangements with feet or footless, with NEMA C-face, D-flange, or P-base brackets. Low-inertia, fast-accelerating rotor, constructed of pres-

Circle 529 on Page 19



sure-cast aluminum, is dynamically balanced to movement tolerances as precise as 0.0002 in. to prolong bearing life and produce quiet operation. Low-inertia rotor and increased accelerating torque combine with improved double-end ventilation to provide frequent stops and starts without risk of overheating. **Reliance Electric & Engineering Co.**, 24701 Euclid Ave., Cleveland 17, Ohio. F

Circle 694 on Page 19

Bearing Material

has ceramic or glass fibers encapsulated within Teflon

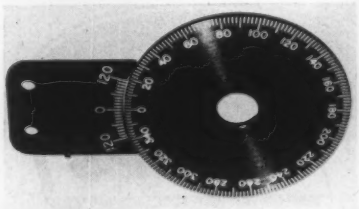
New material for bearings combines lubricity of Teflon with greatly improved resistance to wear and cold flow. Material, a combination of ceramic or glass microfibers, Teflon, and molybdenum disulfide, achieves excellent resistance to cold flow and wear through reinforcing effect of long fibers which are encapsulated within plastic. Bearing material is particularly suited for sleeve or washer-type bearings designed for operation at ambient temperatures from −350 to +550 F, and in corrosive atmospheres where lubrication is not possible or desirable. **Rogers Corp.**, Rogers, Conn. B

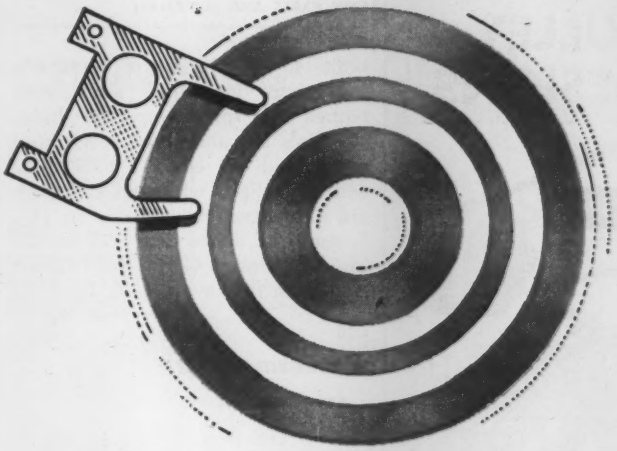
Circle 695 on Page 19

Engraved Dials

with bores from 0.12 to 0.25 in.

Precision-engraved disc dials are





METAL GRAPHITE CONTACTS

AND RADIO INTERFERENCE NOISE LEVELS . . .

Since shielding and filters to reduce radio noise caused by sliding contacts are often cumbersome and always costly, it is essential that contact materials be used which, in themselves, create the least radio noise interference.

Stackpole Laboratory tests backed by extensive field experience indicate that Stackpole silver graphite operating against silver rings give satisfactory results on most sliding contact applications calling for low radio noise levels. Good radio interference reduction results are likewise obtained with Stackpole electrographite grade L31 contacts operating against electrographitic rings, as well as against silver and gold rings.

In addition to reducing radio noise interference, sliding contacts must also be able to operate at high altitudes under high pressure conditions in dry, inert atmospheres, with excess moisture, and with oil vapor. All of these ambients have come within Stackpole experience with the resulting development of materials which work well under such conditions.

Give us the contact radio noise reduction problem and the chances are excellent that Stackpole can recommend materials or testing procedures to solve it.

STACKPOLE CARBON COMPANY, *St. Marys, Pa.*

BRUSHES • CONTACTS • VOLTAGE REGULATOR DISCS
CATHODIC PROTECTION ANODES • SEAL RINGS • CLUTCH
RINGS • FRICTION SEGMENTS • CHEMICAL ANODES
POROUS CARBON and dozens of other related products.

STACKPOLE

custom-engineered

CONTACTS/BRUSHES

Circle 530 on Page 19

3 PULLEY DESIGNS

CONSTANT SPEED — Hi-Lo Automatic Pulleys employ an exclusive cam and cam follower assembly to maintain desired speed ratio over a wide range of load variation. They provide high shock absorbency against sudden changes and eliminate "drag" due to temporary overload. Sizes: ¾ to 5 hp. at 1750 rpm. Speed ratios: 1.75 up to 2.6 to 1. *Request Bulletin A458.*

HIGH RATIO — Hi-Lo Hi-Ratio Pulleys provide an extremely wide range of speeds for constant speed motors up to 1 hp. Double variable pitch feature automatically adjusts driver and driven belt speeds in accordance with distance from motor. Sizes and speed ratios: fractional to ½-hp. model up to 6 to 1, fractional to 1-hp. model up to 7½ to 1. *Request Bulletin B455-2.*

ECONOMY — Hi-Lo FHP Pulleys are low cost, high quality, compact units. They feature exclusive Hi-Lo cam design for positive speed control over a wide range of load variation. Available in three sizes: ½, ¾ and 1 hp. Speed ratios: 2 to 1 for ½ and ¾-hp. models, 2½ to 1 for 1-hp. model. *Request Bulletin C458.*

Give application details for specific information. Ask for prices.

Manufactured by HI-LO MANUFACTURING COMPANY

Nationally Distributed By
LOVEJOY FLEXIBLE COUPLING COMPANY
4968H West Lake St.
Chicago 44, Ill.

Circle 531 on Page 19

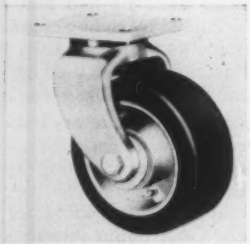
available in a variety of diameters, engravings, and shaft sizes, with pinned or split-clamp-type hubs. M1 dials are aluminum black anodized, and all engraving is filled with MIL-Spec white filler. Standard diameters are available in 1½, 3, and 4 in., bores from 0.12 to 0.25 in. **PIC Design Corp.**, 477 Atlantic Ave., East Rockaway, L. I., N. Y. D

Circle 696 on Page 19

Aluminum Casters

are corrosion resistant

New 5 and 6-in. light-duty aluminum casters have sealed bearings and 2-in. wide Neoprene rubber-tread wheels. Series BS (shown) swivel casters and Series BT rigid units are for use in packing, bottling, and food-processing plants and in other applications where corrosive



conditions prevail or where casters are regularly left standing out of doors. Casters incorporate corrosion-resistant features of sanitary line units. Wheel and swivel bearings are sealed, and horn surfaces are smooth with no cracks or projections to catch dirt. **Bassick Co.**, Bridgeport 5, Conn. B

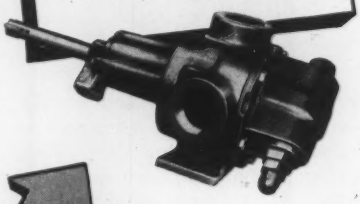
Circle 697 on Page 19

Limit Switch

is three-circuit type

Loxswitch three-circuit limit switch can be used in applications such as tying together two or three functions without cost of an additional relay, and controlling a motor and simultaneously starting or stopping a timer or other control. Model L100WTR, for clockwise operation, has two normally open and one normally closed circuits. Model L100WTL, for counterclockwise operation, has two normally open and one normally closed circuits. Both switches are readily reversible to give one normally open and two

BE SURE . . . SPECIFY
HIGH PERFORMANCE
WAYNE
PUMPS



EFFICIENCY GOES UP

- ROLLING GEAR DESIGN
- HYDRAULICALLY BALANCED
- 3 TO 500 GPM
- PRESSURES TO 200 PSI

Put the newly designed Wayne Rotary Pumps on your equipment and boost efficiency and reduce costs. There's a Wayne Rotary Pump for every type of equipment to pump all types of products—from glue to gasoline . . . syrup to toluene.

Wayne's gear-within-a-gear pumps now have improved hydraulic balancing, new seals and mounting arrangements . . . available in sizes from 3 to 500 gallons per minute. Whether you require one pump for your plant, or many for the equipment you manufacture, there is a long-life Wayne design to save you money.

GET NEW DATA

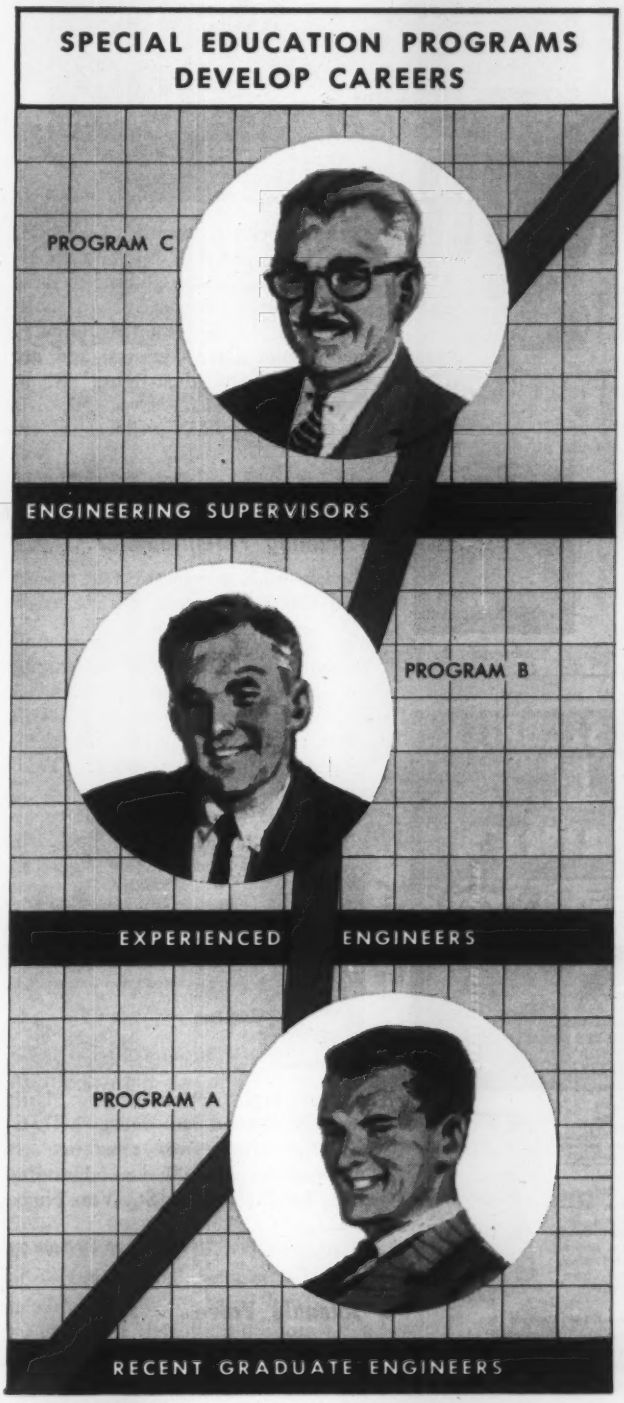
Ask your Wayne representative to recommend the right iron, bronze or special metals construction for your pump application. Send for the new Wayne Rotary Pump Engineering Manual.

THE WAYNE PUMP COMPANY
Industrial Division
Fort Wayne 4, Indiana
Div. Symington Wayne Corp.

Wayne PUMPS

Circle 532 on Page 19

How far can an engineer go at AC?



AC's instrumentation projects offer you a bright future of growth and job satisfaction, if you qualify. You can work on the AChiever inertial guidance system or many other electromechanical, optical and infra-red devices. The finest "in house" training programs are available to you. And AC's new R & D group assures a position of leadership in space age developments.

Three advanced education programs can help you enhance your professional status. AC offers them in addition to their educational assistance programs for men who wish to study for advanced degrees in nearby universities.

Program A—for recent graduate engineers—gives you a solid foundation in the theory and application of inertial guidance systems and servomechanisms.

Program B—for experienced engineers—consists of upgrading studies in inertial guidance, servomechanisms, environmental problems, engineering math and physics, plus advanced state-of-the-art courses.

Program C—for all engineering supervisors—involves management training developed by a team of AC executives and University of Chicago industrial relations experts.

AC's new R & D Group is devoted to the Research and Development of advanced systems and components. Current programs include many vital projects: interplanetary navigation and guidance; digital computer development; advanced inertial sensors; passive electromagnetic detection, surveillance and navigation systems; guidance systems for ballistic missiles, space vehicles and aircraft.

If you are a graduate engineer in the electronics, electrical or mechanical fields, or if you have an advanced degree in mathematics or physics, you should talk with the people at AC. Write the Director of Scientific and Professional Employment, Mr. Robert Allen, Oak Creek Plant, Box 746, South Milwaukee, Wisconsin.

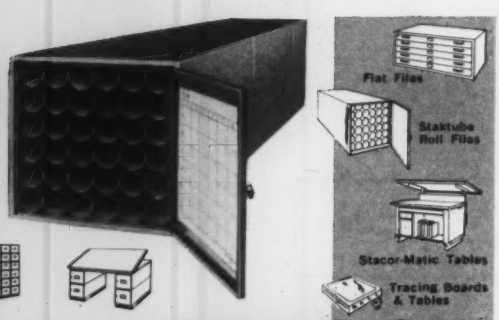
**INERTIAL GUIDANCE SYSTEMS • AFTERBURNER FUEL CONTROLS
BOMBING NAVIGATIONAL COMPUTERS • GUN-BOMB-ROCKET SIGHTS
GYRO-ACCELEROMETERS • GYROSCOPES • SPEED SENSITIVE SWITCHES
SPEED SENSORS • TORQUEMETERS • VIBACALL • SKYPHONE**

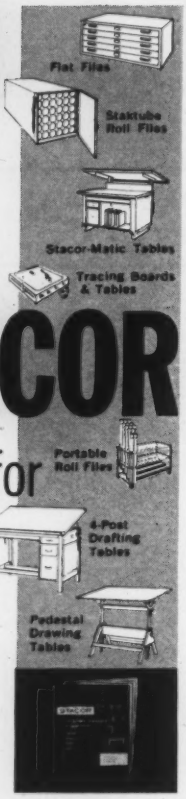
AC SPARK PLUG ⚛ THE ELECTRONICS DIVISION OF GENERAL MOTORS

Please direct inquiries to advertiser, mentioning MACHINE DESIGN

STAKTUBE ROLL FILE

All steel-encased cabinets with steel-rimmed tubes for easy-to-find, safe print storage. Complete with either 36 (2¼" ID) or 9 (4⅜" ID) tubes, 5 lengths, 10 sizes. Files bolt together for stacking to any height. With locks if desired.





SPECIFY STACOR

the line that's engineered for lifetime quality service

Stay with STACOR—all down the line . . . files thru tables. You're investing in efficiency and economy when you specify STACOR Lifetime Quality equipment for all drafting room needs.

Write TODAY for New Complete Catalog.

STACOR EQUIPMENT CO.

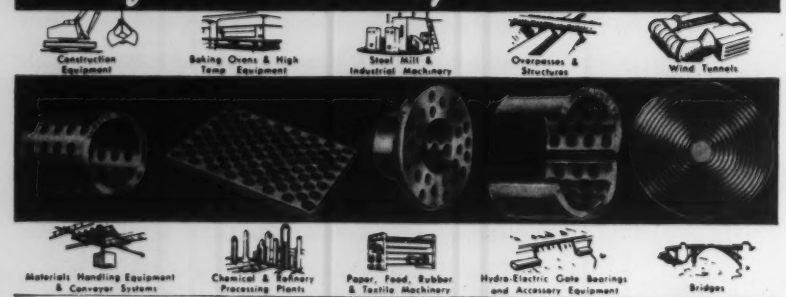
Manufacturers of Quality Drafting and School Equipment

273 Emmet St., Newark 5, N. J.—Bigelow 2-6600

Warehouse Stocks in: Boston, Detroit, Hartford, Los Angeles, Montreal, Philadelphia, Saint John, N. B., San Francisco, Toronto, Washington, D. C.

Circle 533 on Page 19

ASSURED SELF-LUBRICATING SECURITY WITH LUBRITE® Self-Lubricating BEARINGS


Construction Equipment
Baking Ovens & High Temp Equipment
Steel Mill & Industrial Machinery
Overpasses & Structures
Wind Tunnels
Materials Handling Equipment & Conveyor Systems
Chemical & Refinery Processing Plants
Paper, Food, Rubber & Textile Machinery
Hydro-Electric Gate Bearings and Accessory Equipment
Bridges

Lubrite self-lubricating bearings offer great versatility in hundreds of fields where dependability and superior performance are of prime importance.

Lubrite Bearings, with clean, permanent, maintenance-free self-lubrication are designed to withstand severe loadings, temperature extremes, submersion, corrosion and other adverse conditions.

Lubrite may be just the bearing you need in your designs to obtain better results.

Consult our Engineering Department on your application. No obligation.

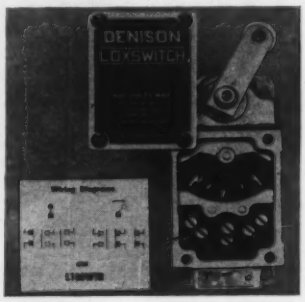
Send for this free 20-page Lubrite Manual No. 55—it contains complete information, technical data and specifications about Lubrite Self-Lubricating Expansion Plates and Bushings. Write today!

Available soon — New Manual No. 56 with complete technical information about LUBRITE SELF-LUBRICATING BUSHINGS, BEARINGS & WASHERS.

Write for your copy.

LUBRITE DIVISION
MERRIMAN BROS., INC.
188 AMORY STREET, BOSTON 30, MASSACHUSETTS

Circle 534 on Page 19



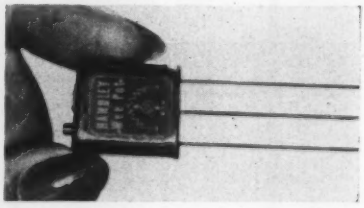
normally closed circuits, and both have ¾-in. conduit opening to allow room for wires. Switches have 70-deg safety overtravel in both directions, fully isolated circuits, heavy solid-silver contacts, and are water, oil, and dust-tight. **R. B. Denison Mfg. Co.**, Dept 3P, 102 St. Clair Ave. N.W., Cleveland 13, Ohio. F

Circle 698 on Page 19

Trimming Potentiometer

withstands acceleration of 100 g

Model 1-WO Weepot wire-wound trimming potentiometer is wound for accurate adjustment to 0.000001 in., using wire as small as 0.004 in diam. Unit withstands 100 g acceleration and 50 g shock. Temperature range is −55 to +140 C with 1.3 w at 40 C. Small worm-gear adjustment, free of backlash,



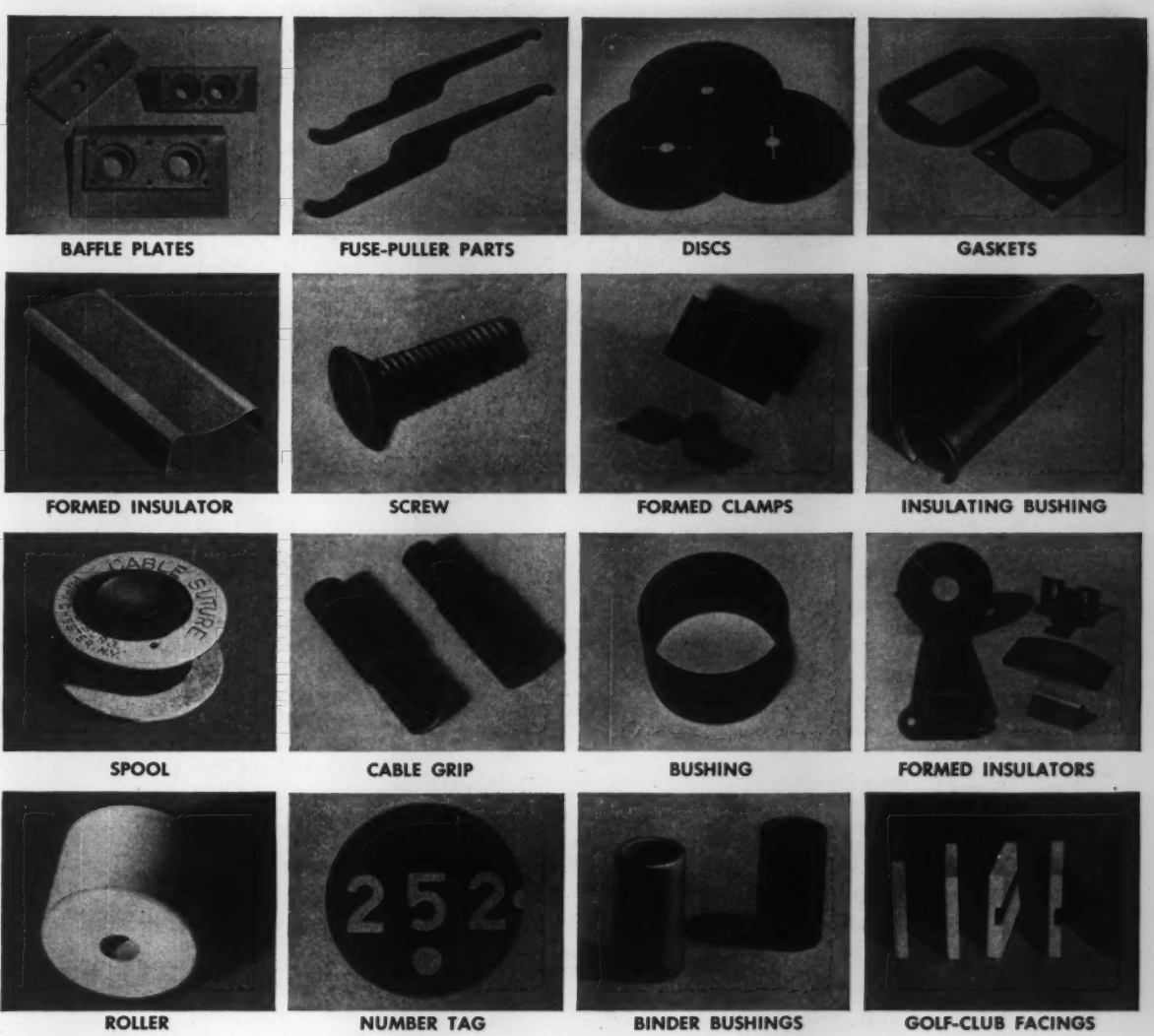
delivers high friction loading. Unit can be sealed to meet MIL-E-5252A. Inductive reactance is measurable at 900 kc. **Handley Inc.**, 14758 Keswick St., Van Nuys, Calif. L

Circle 699 on Page 19

Solenoid Valve

for operating pressures to 3000 psi

No-leak, two-way, pilot-operated solenoid valve controls flow of hydraulic fluid MIL-O-5606 and sim-



FIBRE—the low-cost insulation of 1001 uses

Look what Diamond Vulcanized Fibre can do for you! And look what *you* or CDF can do with *it!*

If you can keep high-quality fibre clear of its worst enemy—moisture—you have the best economical insulating material you'd ever want for high arc-resistance, non-tracking, and long-time dielectric strength.

UNIQUE PROPERTIES • The high tensile, flexural, and impact strengths, the easy workability (ideal for screw machines), the Rockwell hardness (to R80), the light weight (half that of aluminum), the low cost, and the excellent electrical characteristics (arc-resistance up to 150 sec.) of CDF Fibre make it a highly attractive basic insulation for cost-conscious designers and purchasing men. Put these properties to work in your product.

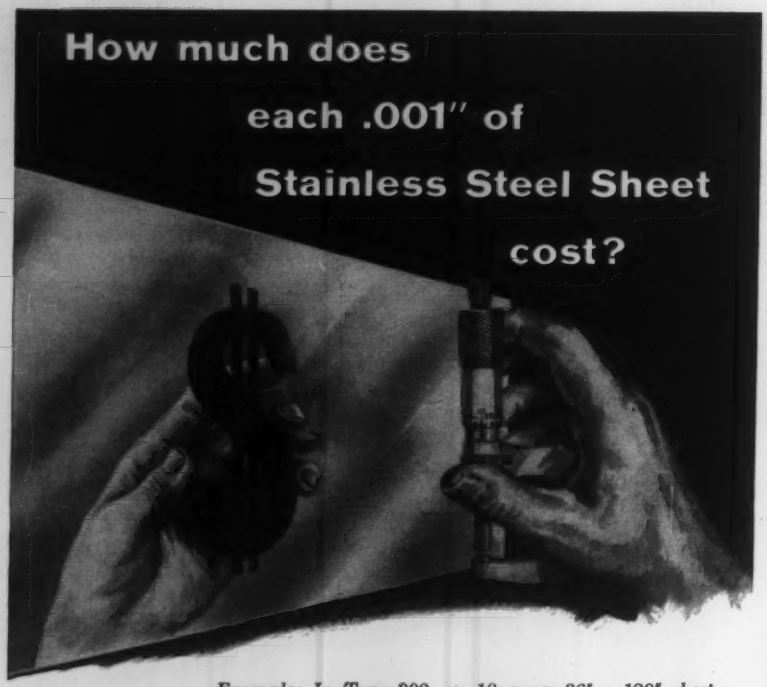
FABRICATION FACILITIES • CDF has excellent and extensive facilities and know-how for turning out finished Diamond Vulcanized Fibre parts—better and more economically than you can do it yourself. We meet *your* specifications and *your* production schedules, and save you time and money in the bargain.

Send us your print or your problem, and we'll return technical literature. For the phone number of the CDF sales engineer nearest you, see Sweet's, Electronics Buyers' Guide, and other directories.

CDF makes Di-Clad printed-circuit laminates, Diamond Vulcanized Fibre, CDF products of Teflon, flexible insulating tapes, Dilecto laminated plastics, Celoron molded products, Micabond mica products, Spiral Tubing, Vulcoid.

CONTINENTAL-DIAMOND FIBRE

A SUBSIDIARY OF THE Budd COMPANY • NEWARK 23, DEL.



Example: In Type 302, an 18 gauge 36" x 120" sheet has a base price of 52¢ per pound. In sheets of this size, each .001" of thickness weighs 1.26 pounds per sheet. Thus, each .001" of unnecessary thickness costs you at least 65.5¢ more per sheet.

On the surface this may seem insignificant, but it has a marked effect on the total price you pay for a given quantity of stainless steel sheet. With cost a factor, this can be important since stainless steel is purchased by weight.

Using the above example, a mere .001" of unnecessary thickness costs you $20.76 more per ton. If you figure the maximum allowable gauge thickness variation of plus or minus (10%), you can readily see that the price you pay for overall sheet thickness could involve much needless cost.

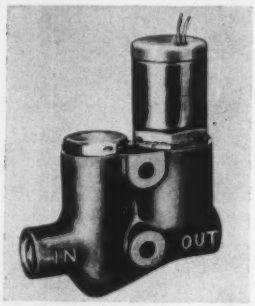
Washington Steel has the equipment and the experience to produce MICROROLD stainless steel to tolerances much closer than standard industry tolerances. Usually money can be saved by first selecting the minimum gauge that will serve the requirements of the application, and then specifying that the thickness be rolled to the light side of the gauge range. This specification involves no cost extra and is standard practice at Washington Steel. (If exact close tolerances must be guaranteed, there is a nominal additional charge.)

Consult your nearest MicroRold Stainless Steel Distributor. He will gladly show you how to save money on your stainless steel purchases.

Washington Steel Corporation
Woodland & Griffith Avenues
9-E Washington, Pa.

Circle 536 on Page 19

ilar liquids. Valve features low power consumption, fast, positive response, and low pressure drop. Of cartridge-type construction, it can be removed quickly for easy maintenance. Unit operates on 0.185 amp, 25 v dc, and operating pressure is 3000 psi. Temperature range is −65 to +275 F. Test



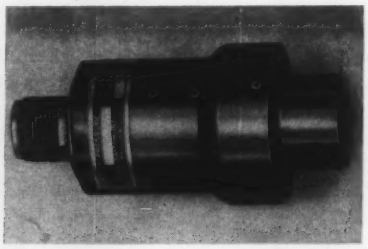
specifications call for proof pressure of 4500 psi, burst pressure of 7000 psi, and zero internal and external leakage. Valve is only 4.53 in. high, 2.63 in. long, and 1.25 in. wide. It weighs only 8 oz. **Fluid Regulators Corp.**, 313 Gillette St., Painesville, Ohio. C

Circle 700 on Page 19

Pressure Switch

has −65 to +300 F ambient-temperature range

Series 1580 pressure switch is a low-cost unit which weighs only 4 oz, and is 3 in. long by 1½ in. diam at widest section. Ambient temperature range is −65 to +300 F, with special units provided for operation to 600 F. Switch is factory set to actuate at any pressure level within range of 0.5 to 4000 psi. All moving parts are contained in an aluminum housing, environmentally sealed by O-rings at each end. Assembly resists corrosive operating media such as water-alcohol solutions, nitric acid, and hydrogen peroxide. Applications include pneumatic, hydrau-



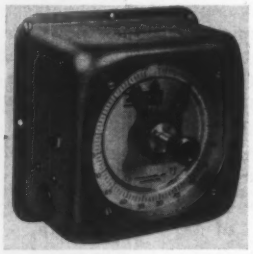
lic, lubricating, fuel, chemical, and gas-pressure systems. Haydon Switch Inc., Waterbury 20, Conn. B

Circle 701 on Page 19

Recycling Controller

for automatic counting and switching

Cyclo-Master recycling controller provides three different arrangements of automatic counting and switching: One-count switching; one-cycle switching; differential (add and subtract) counting and switching. Applications include liquid metering control, interval indication in high-production count; forward and reverse control with preset limits; control of motors, valves, pumps, relays, and signals, size control for wound reels or spools, and container filling. Unit recycles without pause or hesitation between successive cycles to eliminate cumulative error. Mechanism remains in step with uninterrupted counting process, making it suitable for continuous as well as intermittent counting applications. Control-



ler counts at speeds to 1000 counts per min, and operates on 115-v, 60-cycle current. Counter & Control Corp., 4503 W. Brown Deer Rd., Milwaukee 23, Wis. K

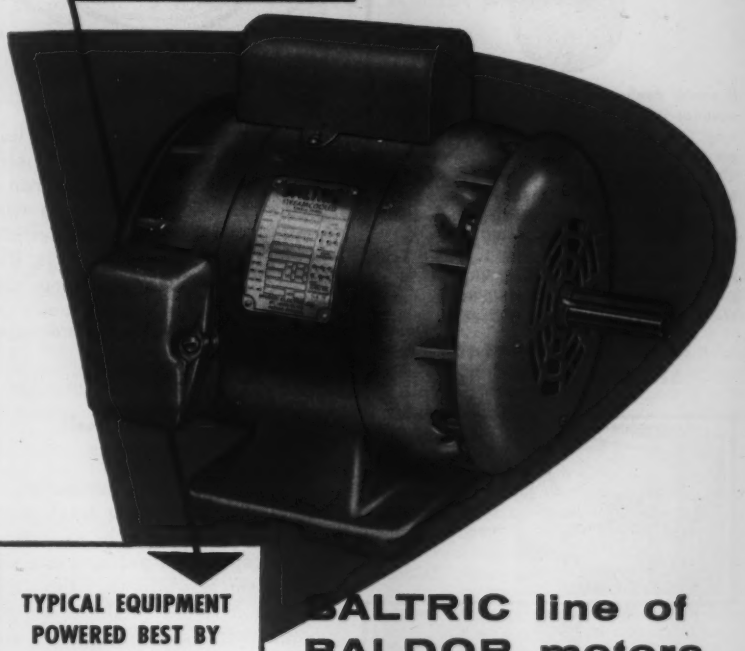
Circle 702 on Page 19

Reusable Seal

for AN 3102 electrical connectors

Reusable seal eliminates the necessity to machine seal grooves or use adhesive compounds. It is for use on most styles of AN 3102-type electrical connectors. Seal has one-piece, rigid construction for easy assembly, and provides metal-to-metal contact of faying surfaces. Very low fastening torques are required to obtain a seal, and seal cannot be

Specially designed with the APPLICATION in mind!



TYPICAL EQUIPMENT POWERED BEST BY BALDOR MOTORS

Blowers
★
Fans
★
Ventilators
★
Agriculture dryers, cleaners, separators
★
Conveyors
★
Woodworking machinery
★
Abrasive saws (masonry & steel)
★
Pumps
★
Compressors
★
Machine tools

BALTRIC line of BALDOR motors

No guesswork here! Now you can stop fitting the machine to the motor.

Famous Baldor Streamcooled Motors featuring TEFC construction, are engineered and designed to fit *specific* applications—your guarantee of getting the *one right* motor that will deliver the power and performance to make your equipment operate at top efficiency.

There's a highly trained and experienced Baldor representative near you who will be happy to show you how this "tailored-to-the-job" type of engineering can help cut costs and improve the performance of your equipment. Contact him direct or write to . . .

BALDOR
ELECTRIC COMPANY
4349 Duncan Avenue • St. Louis 10, Missouri

Over 500 Authorized Sales & Service Distributors in U. S. A.
District Offices: Atlanta • Chicago • Cleveland • Dallas • Dayton • Des Moines • Detroit • Litchfield, Conn.
Los Angeles • Milwaukee • Minneapolis • New York • Kansas City, Mo.
Oakland • Philadelphia • Portland, Ore. • Syracuse

Circle 537 on Page 19

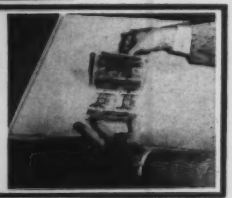
are you spending $12.00 for a one cent job?

If you're duplicating drawing details, you're squandering precious hours of costly drafting time. STANPAT, the unique tri-acetate that is pre-printed with your standard and repetitive blueprint items, cuts time involved from 3 hours to 15 seconds! Figured at current pay rates, this means a $12 job at less than one cent . . . the STANPAT way. Easily transferred to your tracings by an adhesive back or front, STANPAT relieves your engineer of time-consuming and tedious details, freeing him to concentrate on more creative work.

here's how simple the STANPAT method is!

PEEL the STANPAT from its backing.

PLACE the STANPAT into position on the tracing.



PRESS into position . . . will not wrinkle or come off.

STANPAT is available in two types of adhesive backs:

- Rubber base for standard drafting and tracing papers
- Resin base to prevent leaching for papers that contain oils

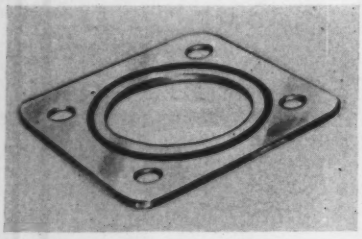
But whatever the application may be, there's a STANPAT product for your specific needs. Stanpat has a guaranteed shelf life of one year from date appearing on tab end. For further information and technical assistance, complete the coupon below and mail.

STANPAT CO. Whitestone 57, N.Y., U.S.A.
Phone: Flushing 9-1693-1611

☐ Please quote on enclosed samples.
☐ Kindly send me STANPAT literature and samples.
Dept. 130

Name_____
Title_____
Company_____
Address_____

Circle 538 on Page 19



distorted beyond its elastic limits due to precision-controlled confinement of seal gland. Seal can be used on all style connectors where configuration provides sufficient land area to accommodate it. **Parker Seal Co.**, 10567 Jefferson Blvd., Culver City, Calif. L

Circle 703 on Page 19

Epoxy Compound

for encapsulating small electrical components

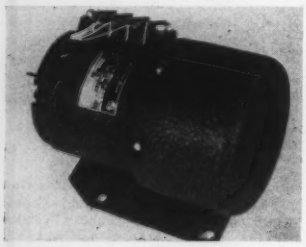
Hysol 10-80 epoxy compound encapsulates by dipping small electrical components such as ceramic-wafer capacitors, resistors, and small transformers. Black thixotropic, viscous material produces an even, nondripping coat on pieces up to 1 in. cube. When some relative motion is produced between system and part being dipped, viscosity at part reduces sharply so that compound can flow evenly over part. On withdrawal, viscosity rises so that no dripping occurs, even at cure temperatures to 160 C. Compound has passed temperature and immersion cycling tests set down by MIL - C - 11015A. **Houghton Laboratories**, Olean, N. Y. N

Circle 704 on Page 19

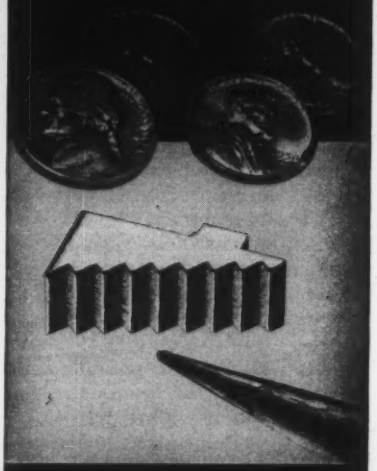
Electric Motor

is ¼-hp, totally enclosed unit

Totally enclosed, self-cooled, ¼-hp, 3300-rpm electric motor operates from 115-v ac, 60-cps, single-



Only 8 Cents . . . for this intricate Minicast part . . .



in quantities of 100,000

Here is another dramatic example of the benefits to be gained from the new Minicast precision process. In addition to an unusually low per unit cost for the part, strict specifications had to be met.

For example, the Minicast process had to provide

- an average maximum radius of .003 on the teeth
- specific tolerances of plus or minus .001
- no tolerance greater than plus or minus .003
- and produce the parts in non-machinable stellite

If you use intricate parts in similar quantity ranges, chances are the Minicast process is your answer to lower costs.

Get the complete story . . . Write for this new descriptive brochure . . . it's free of course

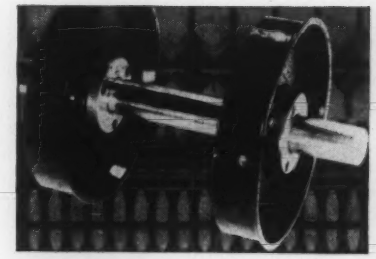
Casting Engineers DIV.

2321 NORTH BOSWORTH AVENUE CHICAGO 14, ILLINOIS

Circle 539 on Page 19

PRODUCT-DESIGN BRIEFS FROM DUREZ

- **Impact strength comes down in price**
- **Fast-curing phenolic cures a cost problem**
- **new idea for closures**



High impact at low cost

These big pulleys help drive huge spinning frames made by Roberts Co., Sanford, N. C., a leading manufacturer of textile machinery.

Until recently, the pulleys were made of stamped metal or heavy cast iron. Designers looked for a better material—strong, dimensionally stable, low in cost. They found it in *Durez 18683*.

This new sisal-filled phenolic solves the cost problem of high-impact parts in three ways:

1. It costs only pennies more than general-purpose wood-flour-filled phenolics.
2. It molds by simple compression or transfer methods, using standard presses, standard pressures, standard dies.
3. It cures as fast as general-purpose compounds.

Durez 18683 molds dimensionally stable parts with impact strength of 1.4 ft. lb./in. Molded parts are self-extinguishing, have excellent resistance to humidity, and can meet U/L requirements for attached electrical contacts. You'll find that *18683* opens the way to savings on hundreds of applications where higher-cost materials are used now.

Consider it for heater and air-conditioner housings, instrument panels. Specify it for gears, wheels, pulleys, electric motor end bells—wherever you need impact strength and want it at lower cost.

The sooner you investigate *Durez 18683*, the sooner you can start saving with it! For bulletin, data sheet and/or evaluation sample, mail the coupon today.

Torrid tempo

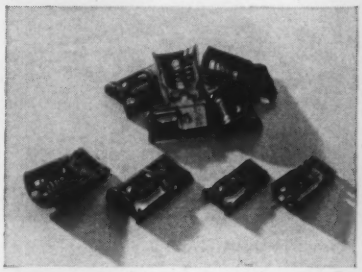
Rapid production is beating out a new rhythm of lowered costs for the makers of these small lamp sockets (center column), Noma Lites, Inc.

The key notes are smart redesign, use of multi-cavity molds, and an exceptionally fast-curing Durez phenolic.

Formerly, the manufacturer bought one-piece sockets, forced metal screw shells into them, applied pitch to protect against moisture, then laboriously soldered in the wires.

Zip! Now, threads are molded into the split sockets by the molder, Holyoke Plastics Company Inc. Wires are laid across the socket halves. A simple metal clip joins the halves and pierces the wires with contacts.

Whoosh! Socket halves are molded 80 at a time. Into the molds goes speedy *Durez 265*, general-purpose compound that cures in a few seconds. Even at this dizzy rate, its batch-to-batch uniformity assures consistent molding.



Hurry! Want to snap things up a bit? *Durez 265* can probably help you do it. To see how, dash right over to your molders. Or shoot us coupon for data on *265* and other GP molding compounds.

A cap can be pretty

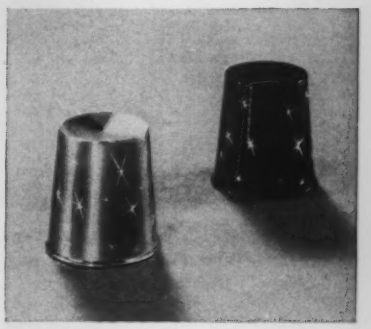
Not so long ago, you couldn't get this decorative effect in a molded plastic closure. Now you can.

It's done by wiping color into the debossed design. Debossing used to be the crux of the problem, because of the undercuts. It was impossible to make a workable mold cavity by machining, hobbing, or casting.

The solution: electroforming. The mold is built up in nickel around a soft, resilient master, which is then withdrawn from the cavity.

The process is a development of Armstrong Cork Company and Electromold Corporation. It gives the designer a new freedom—permits intricate textured effects like leather and wood grain, as well as the simpler ones you see here.

Durez is in the picture, too. Versatile phenolics, especially formulated for bottle and container caps, provide the requisite impact strength, resist chipping and cracking, and do not bleed when in contact with alcohol. If these qualities might help you uncork a closure idea or unbottle a bottleneck, we suggest you contact your molder on the use of Durez phenolics for closures.



For more information on Durez materials mentioned above, check here:

- ☐ High-impact low-cost phenolic, *Durez 18683* Bulletin and data sheet
- ☐ Evaluation sample of *Durez 18683*
- ☐ *Durez 265* (data sheet) and descriptive Bulletin 400

Clip and mail to us with your name, title, company address. *(When requesting samples, please use business letterhead.)*

DUREZ PLASTICS DIVISION

509 WALCK ROAD, NORTH TONAWANDA, N. Y.

HOOKER CHEMICAL CORPORATION

HOOKER CHEMICALS PLASTICS

Circle 540 on Page 19

Want quick, correct solutions to your heating problems?

Call the Chromalox man for the **ANSWERS**

No matter what heating problem you have, there's a Chromalox electric heating unit of the type and size you need.

Your Chromalox Representative—the man with the answers to your heating problems, routine or unusual—has over 15,000 standard types, sizes and ratings to choose from and many of these are stocked in quantity for immediate use. Moreover, Chromalox has the design and manufacturing facilities to build promptly special elements to fit your special requirements, plus a complete range of controls and accessories. For instance . . .

- Strip heaters in lengths up to 96 inches, in wattages up to 1500 with temperatures up to 1200°F, as well as new heater bands designed specifically for injection and extrusion barrels.
- Chromalox Electric Tubular Heaters engineered and built to suit your design. No quick compromise with an adapted element, but a custom-designed component with the exact characteristics necessary to give years of top performance to your product.
- Specify Chromalox Electric Cartridge Heaters, and you get more dependable spot heat with close thermal control. Exclusive design gives positive lead wire protection against flexing, abrasion, moisture. Also available in new extra-high-temperature models with Inconel® sheath to provide maximum heat concentration.
- New Microfin® units for space heaters and process air in ovens and ducts provide safe, fast heating, and are workable into limitless configurations to provide maximum wattage in a given space.
- Packaged elements for Far-infrared, immersion, and circulation heating.
- Lightweight, flexible Pre-Fab woven elements—silicone-molded or laminated—for confined spaces, and areas requiring small amounts of heat.

For an on-the-spot heating analysis at no obligation, just call your Chromalox Direct Factory Representative. A call to your "man with the answers" (see listing on opposite page) will put Chromalox Service to work for you at once.

4988

CHROMALOX® Electric Heat

Edwin L. Wiegand Company

7575 Thomas Boulevard, Pittsburgh 8, Pennsylvania • CHurchill 2-6400

Call Chromalox

for the man with the
ELECTRICAL ANSWERS
to your heating problems

ATLANTA 9, GA.
Applebee-Church, Inc.
1389 Peachtree St., N.E.
Trinity 5-7244

BALA-CYNWYD, PA.
J. V. Calhoun Company
349 Montgomery Ave.
Mohawk 4-6113
Greenwood 3-4477

BALTIMORE 18, MD.
Paul V. Renoff Company
333 East 25th St.
Hopkins 7-3280

BINGHAMTON, N. Y.
R. P. Smith Co., Inc.
94 Henry St.
Phone 4-7703

BLOOMFIELD, N. J.
R. L. Faber & Assoc., Inc.
1246 Broad St.
Edison 8-6900
New York: Worth 4-2990

BOSTON 11, MASS.
Leo C. Pelkus & Co., Inc.
683 Atlantic Ave.
Liberty 2-1941

BUFFALO 2, N. Y.
Niagara Electric Sales Co.
505 Delaware Ave.
Summer 4000

CHARLOTTE 2, N. C.
Ranson, Wallace & Co.
116½ E. Fourth St.
Edison 4-4244
Franklin 5-1044

CHATTANOOGA 1, TENN.
H. R. Miles & Associates
P. O. Box 172
Amherst 5-3862

CHICAGO 5, ILL.
Fred I. Tourtelot Company
407 S. Dearborn St.
Harrison 7-5464

CINCINNATI 8, OHIO
The Smysor Company
1046 Delta Ave.
Trinity 1-0605

CLEARWATER, FLA.
J. J. Galleher
617-A Cleveland St.
P. O. Box 1376
Phone 3-7706

CLEVELAND 13, OHIO
Anderson-Bolds, Inc.
2012 W. 25th St.
Prospect 1-7112

DALLAS 26, TEX.
L. R. Ward Company
3009 Canton St.
Riverside 1-9004

DAVENPORT, IOWA
Volco Company
215 Kahl Building
Phone: 6-5233

DENVER 2, COLO.
E. & M. Equipment Co.
2415 Fifteenth St.
Glendale 5-3651
Genesee 3-0821

DES MOINES 14, IOWA
Midwest Equipment Co.
of Iowa
842 Fifth Ave.
Cherry 3-1203

DETROIT 38, MICH.
Carman Adams, Inc.
15760 James Couzens Hy.
University 3-9100

HOUSTON 3, TEX.
L. R. Ward Company
3605 Polk Ave.
Capitol 5-0356

INDIANAPOLIS 8, IND.
Couchman-Conant, Inc.
1400 N. Illinois St.
Station A, P. O. Box 88023
Melrose 5-5313

KANSAS CITY 6, MO.
Fraser D. Moore Co.
106 E. 14th St.
Victor 2-3306

LOS ANGELES 15, CAL.
Montgomery Brothers
1053 S. Olive St.
Richmond 7-9401

MIDDLETOWN, CONN.
Dittman and Greer, Inc.
33 Pleasant St.
Diamond 6-9606

MILWAUKEE 3, WIS.
Gordon Hatch Co., Inc.
531 W. Wisconsin Ave.
Broadway 1-3021

MINNEAPOLIS 4, MINN.
Volco Company
831 S. Sixth St.
Federal 6-3373

NASHVILLE 4, TENN.
H. R. Miles and Associates
2500-B Franklin Rd.
Cypress 2-7016

NEW YORK CITY, N. Y.
See "Bloomfield, N. J."

OMAHA 2, NEB.
Midwest Equipment Co.
1614 Izard St.
Atlantic 7600

PHILADELPHIA, PA.
See "Bala-Cynwyd, Pa."

PITTSBURGH 6, PA.
Woessner-McKnight Co.
1310 Highland Building
115 S. Highland Ave.
Emerson 1-2900

PORTLAND 9, ORE.
Montgomery Brothers
1632 N.W. Johnson St.
Capitol 3-4197

RICHMOND 26, VA.
O. M. Thompson
Westhampton Station
P. O. Box 8762
Atlantic 8-8758

ROCHESTER 4, N. Y.
Niagara Electric Sales Co.
133 Clinton Ave. S.
Hamilton 6-2070

ST. LOUIS 1, MO.
C. B. Fall Company
317 N. 11th St.
Suite 1001
Chestnut 1-2433

SAN FRANCISCO 3, CALIF.
Montgomery Brothers
1122 Howard St.
Underhill 1-3527

SEATTLE 4, WASH.
Montgomery Brothers
911 Western Ave.
Main 4-7297

SYRACUSE 6, N. Y.
R. P. Smith Co., Inc.
2507 James St.
Howard 3-2748

WICHITA 2, KAN.
Fraser D. Moore Co.
695 Geo. Washington Blvd.
Amherst 2-5647

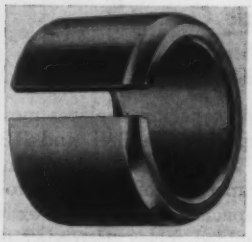
CHROMALOX
Electric Heat
INDUSTRIAL · COMMERCIAL · RESIDENTIAL
EDWIN L. WIEGAND COMPANY
7875 THOMAS BLVD., PITTSBURGH 8, PA.

phase power. It conforms to Specification CC-M-636. Unit measures 4¼ in. diam by 6¾ in. long and weighs 10 lb. **Electro Products Div., Western Gear Corp.,** 132 W. Colorado Blvd., Pasadena, Calif. L

Circle 705 on Page 19

Tension Bushes

for oscillating or low-rpm bearing uses



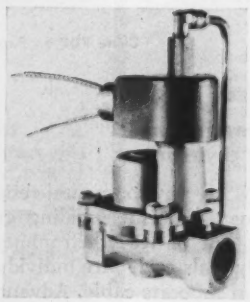
Tension Bushes are hollow cylinders slotted lengthwise and made of heat-treated spring steel of high elasticity and excellent wear resistance. They are held in place by spring tension and can be exchanged easily when worn. Bushes are suited for oscillating or low-rpm bearing applications where there is considerable wear and little lubrication possible. **John Gillen Co.,** 2540 S. 50th Ave., Cicero, Ill. I

Circle 706 on Page 19

Solenoid Valve

is internally pilot operated

Two-way, normally open solenoid valve handles steam, hot gases, and light liquids up to 350 F, in ⅜, ½, and ¾-in. pipe sizes. Valve has full pipe-area orifices. It is internally pilot operated, having a forged brass body and bonnet. Renewable Teflon discs provide tight seating at pressures to 125 psi. All parts in



Having PUMP PROBLEMS?

Let Gusher Help You

Write Today for information

Ruthman

MACHINERY CO.

Circle 542 on Page 19

No. 5 of a series

Eastman 910 Adhesive solves another production bottleneck

Electro-Voice, Inc., of Buchanan, Michigan, manufactures miniaturized phonograph cartridges, called "Power-Point," for high-fidelity audio systems.

The cartridge consists of a jewel-tipped ceramic transducer in a plastic boot, encased in nylon. Assembly is handled on a conveyorized production line and depends on rapid bonding of the components to obtain economical high-volume output.

The critical bonding problem is solved with Eastman 910 Adhesive.

Immediately following hand assembly, a drop of the adhesive is applied to the tiny components. *Moments later, a permanent bond is formed*...and the unit moves on, without delay.

Eastman 910 Adhesive is making possible faster, more economical assembly-line operations and new design approaches for many products. It is ideal where extreme speed of setting is important, or where design requirements involve joining small surfaces, complex mechanical fasteners or heat-sensitive elements.

Eastman 910 Adhesive is simple to use. No mixing, heat or pressure is required. Upon spreading into a thin film between two surfaces, setting begins immediately. With most materials, strong bonds are made in minutes.

What production or design problem can this unique adhesive solve for you?

Bonds Almost Instantly ...Without Heat, Pressure or Catalyst

For a trial quantity (⅓-ounce) send five dollars to Armstrong Cork Company, Industrial Adhesives Division, 9109 Dean Street, Lancaster, Pa., or to Eastman Chemical Products, Inc., Chemicals Division, Dept. M-9, Kingsport, Tenn.

Circle 543 on Page 19

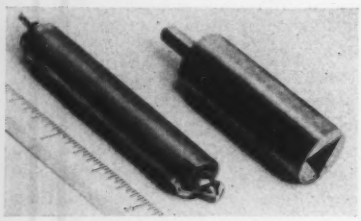
contact with media handled are brass, Teflon, stainless steel, or Viton A. Completely packless, valve has no stuffing boxes or sliding glands. Listed for ac service, valve can also be supplied for dc service. It can be mounted in any position, eliminating piping problems. **Automatic Switch Co.**, Hanover Road, Florham Park, N. J. D

Circle 707 on Page 19

Ceramic Capacitor

in extruded and molded forms

Ceramic capacitor replaces most paper capacitors in 0.01 and 0.25-mf range and mica capacitors in no-drift capacities of 300 mmf to 0.01 mf. Capacitor is ceramic in extruded and molded forms. Extruded model is a tube with triangular cross-bracing which performs as a structural



core and as a surface area to increase capacitance. Molded type is of solid construction which can be manufactured automatically in one piece without leads or terminals. Both types are suitable for high temperature. Molded unit withstands extreme temperatures, due to elimination of soldered terminals. Capacitor is noninductive and has indefinite life since no active elements are used. It reduces mounting area, cost, and installation time, and is suitable for printed circuitry and dip-soldering techniques. **Packard Bell Electronics Corp.**, 12333 W. Olympic Blvd., Los Angeles, Calif. L

Circle 708 on Page 19

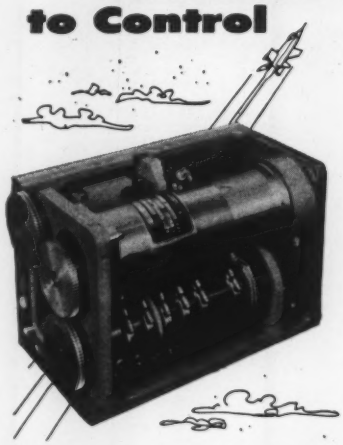
Electrical Plugs

lightweight units resist environment

Class MS-R environmental-resistant plugs use a moisture-sealing grommet at exit of wires. Grommet effectively seals each wire individually and also supports cable. Advantages

SPECTROL PRECISION MECHANISMS

Pilot to Cockpit to Control



When a test pilot rockets into the outer atmosphere for the first time driving experimental craft such as North American's X-15, he'll feel as though he's been there before.

Before his first actual flight, the pilot trains for many hours in "dry land" rocket craft. There, he learns to cope with upper atmosphere problems as posed by an analog computer. Every time he touches a control, the computer responds and the result appears on the instrument panel in the training cockpit. The entire bank of instruments reacts as though he were really "up there." In this way, the pilot meets every conceivable situation long before he takes his powerful bird aloft.

And what does Spectrol have to do with this important training program?

Spectrol makes the link that joins the computer and the bank of instruments in the cockpit. This link, known as a servo repeater, translates the computer's information into meaningful dial readings. As you know, such information must be transferred quickly and accurately.

Spectrol servo repeaters do just that. Key specifications for a typical unit now in production are:

Maximum velocity: 360°/sec
Acceleration in excess of 7000°/sec²
Static accuracy better than 0.25 deg. at output shaft

Other applications for Spectrol packaged servo repeaters include dial drives on GCA equipment, airborne computers and dc systems in general.

Spectrol PRECISION MECHANISMS free the systems engineer from building functional sub-assemblies. If you need precise logical system modules combining in a *single specification* sub-assemblies using components such as gear drives, clutches, precision potentiometers and servomotors —Spectrol can help.

For complete information, call your nearest Spectrol engineering sales representative, or address Dept. 579.

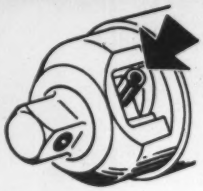
14

SPECTROL

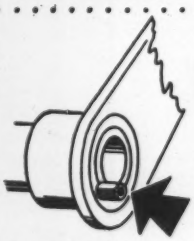
ELECTRONICS CORPORATION
1704 SOUTH DEL MAR AVENUE • SAN GABRIEL, CALIF.

Circle 544 on Page 19

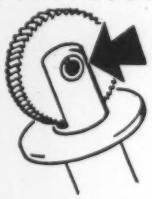
Rollpin replaces 12 different fasteners



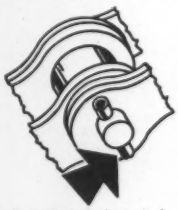
REPLACING A GROOVED PIN . . . in this application, Rollpin serves as a stop pin in a ratchet wrench adaptor. With its light weight and high shear strength, Rollpin functions perfectly . . . cuts assembly costs.



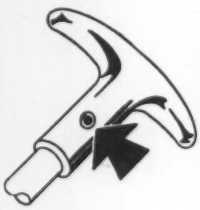
REPLACING A KEY . . . Rollpin demonstrates its ability to do away with precision tolerances, in this heating system damper arm. Faster, cheaper and more satisfactory than previous assemblies.



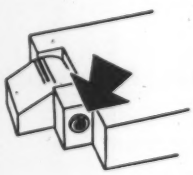
REPLACING A RIVET SHAFT . . . Rollpin serves as an axle for the sparkwheel of a cigarette lighter. No riveting or threading necessary . . . faster assembly. Note flush, clean fit.



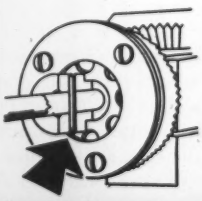
REPLACING A COTTER PIN . . . Rollpin assembly time is shorter, service life ten times longer. Vibration-proof flush fit. Easily removable.



REPLACING A SET SCREW . . . to fasten automobile brake handle a short length Rollpin is self-retained in the hand grip but can easily be driven into over-drilled hole in shaft for simple handle removal.



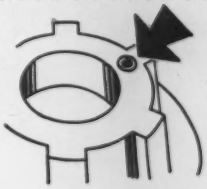
REPLACING A CLEVIS PIN . . . here Rollpin holds firmly in clevis, permits free action of moving member. Rollpin application shown is the plate of a home workshop tool.



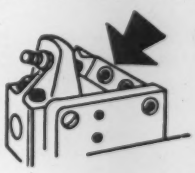
REPLACING TAPER PINS . . . in the assembly of precision differentials eliminated cost of taper pin reamers and the entire reaming operation. Rollpin costs less than a taper pin and installation is cheaper. They remove easily.

REPLACING A HEADED PIN . . . in this hinge pin application, Rollpin is simply and inexpensively driven in place, greatly reducing assembly costs. Constant spring tension holds Rollpin firmly in place . . . eliminates loosening of hinge due to wear.

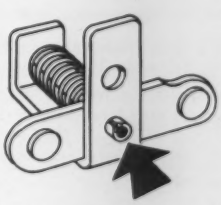
REPLACING A HUB ON A GEAR . . . Rollpin, self-retained in shaft, is simply snapped into molded slot to position sintered gear. This application, by an office equipment manufacturer, effects major savings in assembly. Rollpin's high shear strength is particularly valuable here.



REPLACING A DOWEL PIN . . . Rollpin is used here to prevent rotation of a thrust bearing. No reaming, no special locking. Easily removed. Lowest possible dowel pin cost.



REPLACING A BOLT AND NUT . . . Rollpins act as fasteners and pivots for the linkages in this electric welder. Rollpins may be used with a free fit in outer or inner members depending upon product design requirements.



REPLACING A RIVET . . . Rollpin serves as guide shaft for spring-loaded electrical interlock contacts. This electrical equipment manufacturer reports that rivet failure previously occurred at the clinched end under normal operating impact and vibration.

WHERE CAN YOU USE THIS SIMPLE FASTENER?

Rollpin is the slotted tubular steel pin with chamfered ends that is cutting production and maintenance costs in every class of industry.

Drives easily into standard holes, compressing as driven. Spring action locks it in place—regardless of impact loading, stress reversals or severe vibration. Rollpin is readily removable and can be re-used in the same hole. Made in carbon steel, stainless steel and beryllium copper. Write for samples and information, ELASTIC STOP NUT CORPORATION OF AMERICA, 2330 Vauxhall Road, Dept. R47-94, Union, New Jersey.

Circle 545 on Page 19

ROLLPIN TRADEMARK

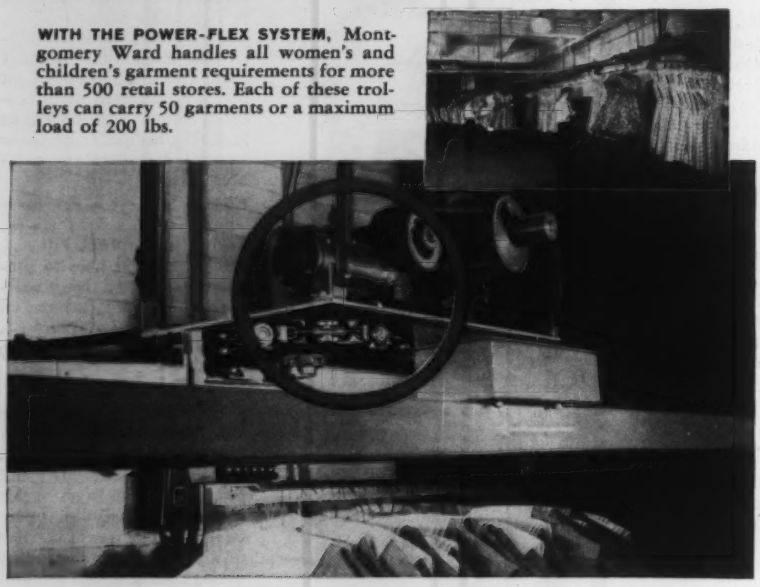
ELASTIC STOP NUT CORPORATION OF AMERICA

2330 VAUXHALL ROAD, UNION, NEW JERSEY

a CM Power-Flex Conveyor using a WINSMITH Speed Reducer

"DELIVERS THE GOODS" FOR MONTGOMERY WARD

WITH THE POWER-FLEX SYSTEM, Montgomery Ward handles all women's and children's garment requirements for more than 500 retail stores. Each of these trolleys can carry 50 garments or a maximum load of 200 lbs.



A CLOSEUP of the Winsmith Model 5 CVD Speed Reducer used to drive the CM Power-Flex Conveyor which features Telematic Dispatch Control. Chain Speed is 40 ft/min.

MONTGOMERY WARD'S DISTRIBUTION CENTER on Varick Street in New York City, is built around a Columbus McKinnon Power-Flex Conveyor System equipped with a Winsmith Speed Reducer. CM's Power-Flex is a power and free system that, in this application, handles as many as 38,000 women's and children's garments in a single 8-hour day. Its advanced design and construction features permitted savings of 50,000 sq. ft. of floor space and untold dollars in operating economies.

COLUMBUS McKINNON specifies Winsmith Speed Reducers for their Power-Flex Systems because high output efficiency, compactness, long service life, minimum maintenance and low initial cost are prime factors.

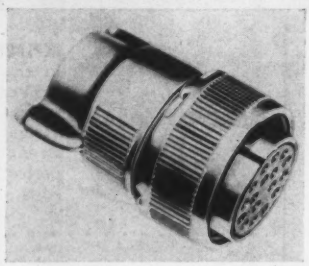
FOR EVERY APPLICATION from 1/100 to 85 H.P.—in ratios from 1.1:1 through 50,000:1—investigate the advantages of standardizing on Winsmith Speed Reducers for your products.

WINSMITH SPEED REDUCERS

WRITE TODAY... for complete selection information and engineering data.

WINSMITH, INC.

16 Elton Street, Springville, (Erie County), N. Y.



of plugs are 30 per cent saving in plug length and 25 per cent saving in weight as compared with older MS-E units. Plugs supersede MS-E types currently in use. **Cannon Electric Co.**, P. O. Box 3765, Terminal Annex, Los Angeles 54, Calif. L

Circle 709 on Page 19

Piston Air Pump

is portable, oilfree unit

Bantam piston-type air pump furnishes clean, odorless, oilfree air in small volume at either high or low pressure. Unit can be used with any temperature, humidity, and damper or pneumatic controls or systems without contamination of lines or

instruments. The 10½-lb pump can be mounted in any position. **Winslow Mfg. Co.**, 3695 E. 10th Court, Hialeah, Fla. O

Circle 710 on Page 19

Panel-Mount Potentiometers

require 1/12 sq in. or less panel area

Trimpot potentiometers with panel-mounting provision are available in resistances from 10 ohms to 1 megohm with wire-wound or carbon-resistance elements. New mounting style is available for all standard Bourns models. Requiring only 1/12 sq in. or less panel area, units feature a self-locking shaft which eliminates use of lock nuts. Multiturn

For a money-saving balance

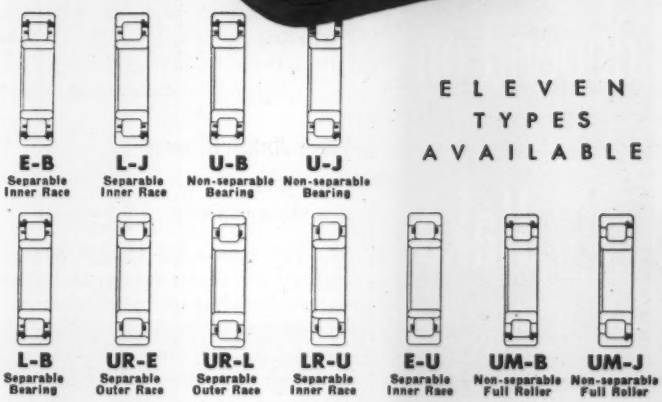
between maximum performance and moderate cost . . .

ROLLWAY Tru-Rol® BEARINGS

Give you more for your bearing dollar

For those hundreds of in-between applications where performance requirements are more exacting than those provided by the ordinary commercial bearing, but where maximum precision would be unneeded precision – specify Tru-Rol for the job.

Tru-Rol Bearings provide above-commercial-grade efficiency . . . at worthwhile savings in cost. Internal clearances are closely controlled. Rollers are equally spaced to eliminate out-of-balance vibration. Each roller is crowned to distribute the load evenly along the full length of the roller. Eleven types available in single and double width bearings, in stamped steel retainer, segmented retainer or full roller construction.



ELEVEN TYPES AVAILABLE

Ask your nearby Rollway Service Engineer to detail the quality you *should be getting* in your "commercial grade" bearings. Or write for the Rollway Tru-Rol catalog showing the full line, and capacity and size ranges. ROLLWAY BEARING COMPANY, INC., Syracuse, N. Y.

ROLLWAY® BEARINGS

COMPLETE LINE OF RADIAL AND THRUST CYLINDRICAL ROLLER BEARINGS

ENGINEERING OFFICES: Syracuse • Chicago • Toronto • Cleveland • Seattle • San Francisco • Boston • Detroit • Pittsburgh • Houston • Philadelphia • Los Angeles

Remet Powdered Metal Part cuts DESIGN and MACHINING costs for Bonney Forge and Tool Works

R. L. Huston, Chief Engineer for Bonney, says, "We went to a powdered metal part on our shifter because the cost of machining this part from steel would have been prohibitive. Also, we would have had to change the entire design of our ratchet. We contacted no less than a dozen fabricators of powdered metal. Reese Metal Products Corp. was the only establishment able or interested in tackling this problem with us."

Bonney now uses Remet shifters in seven of their ratchets. The sintered Remet parts are copper infiltrated iron.

More and more design and production men each year rely on Remet services to help solve problems.

FREE BROCHURE "How to Cut Precision Parts Cost with the Remet Powdered Metal Process" shows how the Reese Corp. can help you. Send for your copy today.

Remet

REESE METAL PRODUCTS CORPORATION

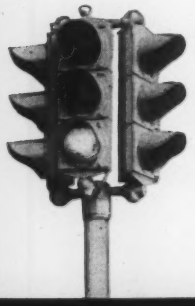
537 Howard Ave., Lancaster 10, Penna.

Gears • Pinions • Cams • Ratchets "Oilless" Bearings • Bushings • Machine and Structural Parts in COPPER • BRASS • IRON • ALLOY STEEL • NICKEL SILVER • COPPER INFILTRATED IRON

Circle 548 on Page 19

Neither dust, dirt, moisture nor temperature changes can affect an Adlake relay. Hermetically sealed mercury-to-mercury contact is quiet, chatterless . . . can't burn, pit or stick. A-plus qualities backed by a century of service. What's your control problem? Write today. No obligation.

a lot at stake?



NO. 1148, one of 4 basic models designed to your control needs.

SEND FOR FREE CATALOG J-8909

Adams-& Westlake

Elkhart, Indiana

depend on A+ Adlake

mercury relays and controls

Circle 549 on Page 19

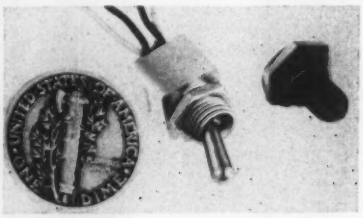
adjustment provides up to 9000 deg of rotation to speed up and simplify adjustment or balancing of circuits. Stainless-steel construction assures compliance with military specifications for vibration, shock, and salt spray. **Bourns Inc.**, P. O. Box 2112, Riverside, Calif. L

Circle 711 on Page 19

Toggle Switch

subminiature unit has long life

Subminiature DPST toggle switch, No. T4301, controls currents in the range of milliamperes. Housed in a cadmium-plated brass case for long-life durability, switch has over-all length of 29/32 in., is 11/32 in. square, and weighs 0.1 oz. Four 10-in. long leads, two white and two red, denote individual circuits and are connected to switch terminals and protected by potted switch base. Silicone-rubber boot



is available to cap toggle for additional protection against moisture. **Hetherington Inc.**, 1420 Delmar Drive, Folcroft, Pa. E

Circle 712 on Page 19

Vane-Axial Blower

has high cooling capacity

SK-2367 vane-axial blower delivers high air-flow rates against high pressures in cooling airborne electronic equipment. Unit delivers 1200 cfm output at .7 in. static pressure (sea level) while operating at 11,500 rpm. Other speeds obtainable with 400-cps, three-phase motor normally

THE WIDEST RANGE OF CAM TIMERS AND TIME CYCLES

2/3 Seconds to 72 Hours in 600 steps

Now you'll find the cam timer you need in Industrial Timer's unequalled selection of standard single-cycle and recycling timers in single and multi-switch types (up to 50 switches). Every model gives you 50 different overall time cycles, ranging from its lowest cycle up to 9 times that cycle. And standard cam construction lets you adjust ON and OFF periods from 2% to 98% of the total time cycle. Here is unsurpassed flexibility in cam timer selection and function.

If you don't find the timer you want in this unmatched range (a highly unlikely possibility), Industrial Timer's unique Timer Kit will help provide the exact timer you need at low cost. With this kit you can design your own prototype, and since the kit components are standard in our line we can reproduce your prototype—in quantity—*at no extra cost.*

For fast delivery on a standard or special Cam Timer check first with Industrial Timer. For more information ask for *Bulletin 200* Synchronous Motor Driven Cam Timers, *Bulletin 201* Multi-Cam Timer Kit, *Bulletin 202* Multi-Cam Switching Devices.

Industrial Timer's complete line of timers also includes: Time Delay Timers, Interval Timers, Running Time Meters, and Programmers. Bulletins describing these are available on request.

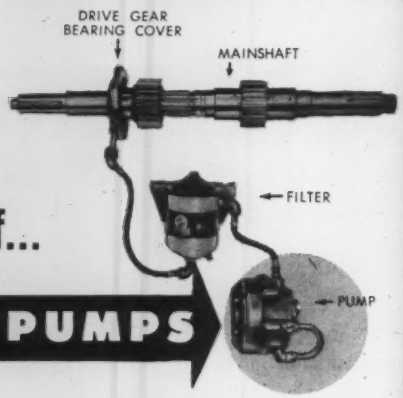
Timers that Control the Pulse Beat of Industry

INDUSTRIAL TIMER CORPORATION

1409 McCARTER HIGHWAY, NEWARK 4, N. J.

CLEAN LUBRICATION INSURED

on Fuller off-highway transmissions with the aid of...



VIKING PUMPS

Clean oil is required for transmissions used in earth moving, mining and other heavy-duty off-highway equipment. Fuller Manufacturing Company, Kalamazoo, Michigan solved that problem by creating pressurized filtration and lubrication systems, which include Viking Pumps, as standard equipment on their transmissions.

Viking Pumps, mounted on power take-offs, assure pressure lubrication to the main shaft bearings and deliver oil to the filter from the transmission case, insuring clean lubrication and long operating life. If discharge pressure becomes too high, oil automatically by-passes the filter through the pump valve, back to the transmission case. The system is simple and practical.

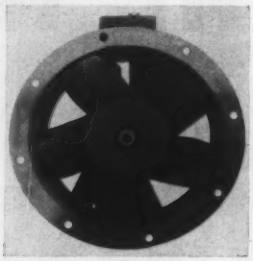
You, too, may find Viking Pumps the answer to your problems of lubrication or liquid moving of other types.

For information write for bulletin 409H.

VIKING PUMP COMPANY

Cedar Falls, Iowa, U.S.A. — In Canada, it's "ROTO-KING" Pumps

See Our Catalog in Sweet's Product Design File



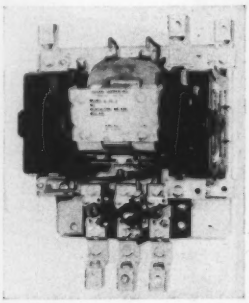
provided are 5400 and 7500 rpm. Dc motor speeds of 6500 and 9000 rpm can also be obtained. Designed to meet all environmental requirements of MIL-E-5272A, unit weighs 11 lb and is 7.44 in. long and 8.5 in. diam. Modifications in size can be made to meet particular performance specifications. **Specialty Blower Div., Torrington Mfg. Co.**, Torrington, Conn. B

Circle 713 on Page 19

Magnetic Starter

has parallel, double-break contacts

Size 4 magnetic starter has new contact structure which minimizes contact bounce and provides longer operational life under severe current demands. Starter is equipped with parallel double-break contacts. Each set of contacts is vertical, dust-safe, nonwelding, and sintered. Each utilizes a flexible jumper, thus provid-



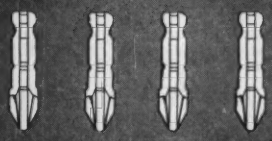
ing more points of contact and more available current paths. Other standard features include molded magnet coils, precision-cast heater coils, contact-block provisions for externally mounting four additional interlock units, and removable lugs for easy installation. Unit, small and compact, is available in a wide range of NEMA enclosures. **Cutler-Hammer Inc.**, 328 N. 12th St., Milwaukee. Wis. K

Circle 714 on Page 19

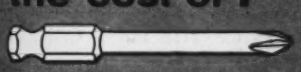
Count on *Continental* for this
2-way saving in bit costs

HY-PRO

You get 4 HY-PRO PHILLIPS Insert Bits



for the cost of 1



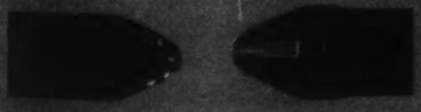
conventional bit

HY-PRO PHILLIPS Insert Bits cost only about one-fourth as much as solid bits, and there is no extra expense for re-sharpening. When a HY-PRO bit wears out, you simply replace it with a new bit . . . and restore *full* driving efficiency at negligible cost.

POWER BIT HOLDERS made in types and sizes to fit all driving tools

HY-PRO PHILLIPS Insert Bits are FORGED

Tested and proved to outlast other bits 2 to 1



Best comparable bit — HY-PRO Phillips Bit

Each bit drove the same number of screws

High strength *forged* HY-PRO Bits are production tested and proved to have an average service life *double* that of the best comparable bits. Many users report even greater margins of extra life for HY-PRO bits, often as high as 4 to 1.

Make your own tests— Compare bit life on your toughest driving jobs. Figure *all* costs. Continental Assembly Specialists will cooperate fully in conducting tests. You'll find HY-PRO Insert Bits and Holders your best buy for lasting bit economy.

Precision control with the same Phillips master tools assures uniformly accurate fit of HY-PRO Phillips Bits and HOLTITE Phillips Screw recesses. Use this proved combination for the top efficiency you need in assembly — especially with power and automatic driving equipment — to avoid downtime, rejects, and weak fastenings. For full information, write: Continental Screw Co., 461 Mt. Pleasant St., New Bedford, Mass.

Only CONTINENTAL makes BOTH PHILLIPS SCREWS and PHILLIPS BITS

MEMBER SCREW RESEARCH ASSOCIATION

CONTINENTAL
SCREW COMPANY, NEW BEDFORD, MASS.
HOLTITE FASTENERS

HOLTITE PHILLIPS AND SLOTTED HEAD
WOOD • MACHINE • TAPPING
THREAD FORMING •
SEMS • NYLOK
HY-PRO PHILLIPS INSERT BITS AND HOLDERS

HY-PRO TOOL COMPANY . . . DIVISION
RESEARCH ENG. & MFG., INC. SUBSIDIARY

Circle 552 on Page 19

42

Complete reprints of major articles now available from MACHINE DESIGN

USE THIS FORM TO ORDER YOUR COPIES TODAY!

Number Copies		Price Per Copy
_____	ELECTRIC MOTORS	$1.00
_____	ELECTRONIC AND ELECTRIC POWER SUPPLIES	1.00
_____	FRICTION-CLUTCH TRANSMISSIONS	1.00
_____	HUMAN-FACTORS ENGINEERING	1.00
_____	DIRECTORY OF MATERIALS—18th Edition	1.00
_____	PRODUCTION CHARACTERISTICS OF ENGINEERING METALS	1.00
_____	DESIGN MANUAL ON ADHESIVES	1.00
_____	NONMETALLIC GASKETS	1.00
_____	ADJUSTABLE SPEED DRIVES (Electrical, Mechanical, Hydraulic)	2.00
_____	ADJUSTABLE-SPEED ELECTRIC-MOTOR DRIVES	1.00
_____	SPEED REDUCERS AND GEARMOTORS	1.00
_____	INTERNAL COMBUSTION ENGINES	1.00
_____	DESIGN FOR FATIGUE LOADING	1.00
_____	WHY MACHINE PARTS FAIL	1.00
_____	STRESS ANALYSIS IN DESIGN	1.00
_____	DIMENSION CONTROL IN DESIGN	1.00
_____	HYDRAULIC SERVO FUNDAMENTALS Vol. I	1.00
_____	HYDRAULIC SERVO FUNDAMENTALS Vol. II	1.00
_____	HYDRAULIC SERVO FUNDAMENTALS Vol. III	1.00
_____	QUALITY CONTROL METHODS	1.00
_____	MULTIPLE CIRCUIT SWITCHES	1.00
_____	ELECTRICAL CONNECTORS	1.00

Number Copies		Price Per Copy
_____	TRANSACTIONS OF THE FIRST CONFERENCE ON MECHANISMS	1.00
_____	TRANSACTIONS OF THE SECOND CONFERENCE ON MECHANISMS	1.00
_____	TRANSACTIONS OF THE THIRD CONFERENCE ON MECHANISMS	1.00
_____	TRANSACTIONS OF THE FOURTH CONFERENCE ON MECHANISMS	2.00
_____	TRANSACTIONS OF THE FIFTH CONFERENCE ON MECHANISMS	3.00
_____	MECHANISMS FOR INTERMITTENT MOTION	1.00
_____	POLYDYNE CAM DESIGN	1.00
_____	EVALUATING ENGINEERS	1.00
_____	ENGINEERING MANAGEMENT	2.00
_____	MEN AND MACHINES	1.00
_____	DESIGNING WITH TEFLON	1.00
_____	DYNAMIC SEALS AND PACKINGS	1.00
_____	MECHANICS OF VEHICLES	2.00
_____	1956 DATA SHEETS	2.00
_____	1957 DATA SHEETS	2.00
_____	1958 DATA SHEETS	2.00
_____	TIPS AND TECHNIQUES—VOL. I (Drafting Aids)	1.00
_____	TIPS AND TECHNIQUES—VOL. II (Engineering Aids)	1.00
_____	PLANNING NEW PRODUCTS	3.00
_____	DESIGN GUIDE FLEXIBLE COUPLINGS	1.00

MACHINE DESIGN

Reader Service
Penton Building
Cleveland 13, Ohio

TOTAL COPIES_____ TOTAL ORDER $_____

Remittance or Company Purchase Order must be enclosed with order.

NAME_____ TITLE_____

COMPANY_____

ADDRESS_____

CITY_____ ZONE_____ STATE_____

(Add 3% to orders in Ohio to cover State Sales Tax)

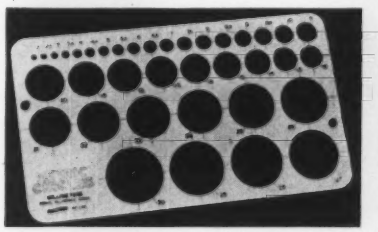
ENGINEERING DEPARTMENT

EQUIPMENT

Metric Circles Template

contains 37 circles from 2 to 30 mm diam

No. 240 metric circles template is the first of a series of templates that incorporate metric system of measurement. Template contains 37 circles from 2 to 30 mm in diam. Circles from 2 to 10 mm are in increments of 0.5 mm, and circles from



11 to 30 mm are in increments of 1 mm. Template is 0.03-in. matte-finish, mathematical-quality plastic, with all circles precision milled with allowance for pencil point. Size of template is 7 x 4 in. **Rapidesign** Inc., P. O. Box 429, Burbank, Calif. L

Circle 715 on Page 19

Photographic Papers

for direct positive copying of documents

New high-speed Autopositive-type photographic papers produce anything from half-size positive intermediates of engineering drawings to enlargements of microfilm positives. Papers yield top-quality positive prints from positive originals when exposed in process camera or enlarger. They also produce reduced or enlarged copies of positive originals. Standard weight is designed for document reproduction and extrathin weight is for use as a reduced-size intermediate of drawings from which final prints can be made. Extrathin weight yields half-size positive intermediates of engineer-

(*Please turn to Page 222*)

SCRAP PILE STEALING YOUR PROFITS?

It can, you know. For every last piece of it represents money — money that belongs in your profit pile, not your scrap pile.

How do you evict this larcenous lodger? It starts disappearing as soon as you call Wheelock, Lovejoy — your local steel service center. W-L offers an extensive variety of special alloy steels — and you get them *cut-to-size*. By ordering your steel as you need it, you can practically eliminate waste. And you save important floor space by reducing your inventory.

Complete W-L facilities — including expert metallurgical service — are at your disposal *now*. See listing below for the W-L Branch nearest you. For complete technical information on grades, applications, heat treating, etc., write today for your FREE COPY of the Wheelock, Lovejoy Data Book.

W-L STEEL SERVICE CENTERS — Cambridge • Cleveland Chicago • Hillside, N. J. • Detroit • Buffalo • Cincinnati
AGENTS — Southern Engineering Company, Charlotte, N. C.; Sanderson-Newbould, Ltd., Montreal & Toronto

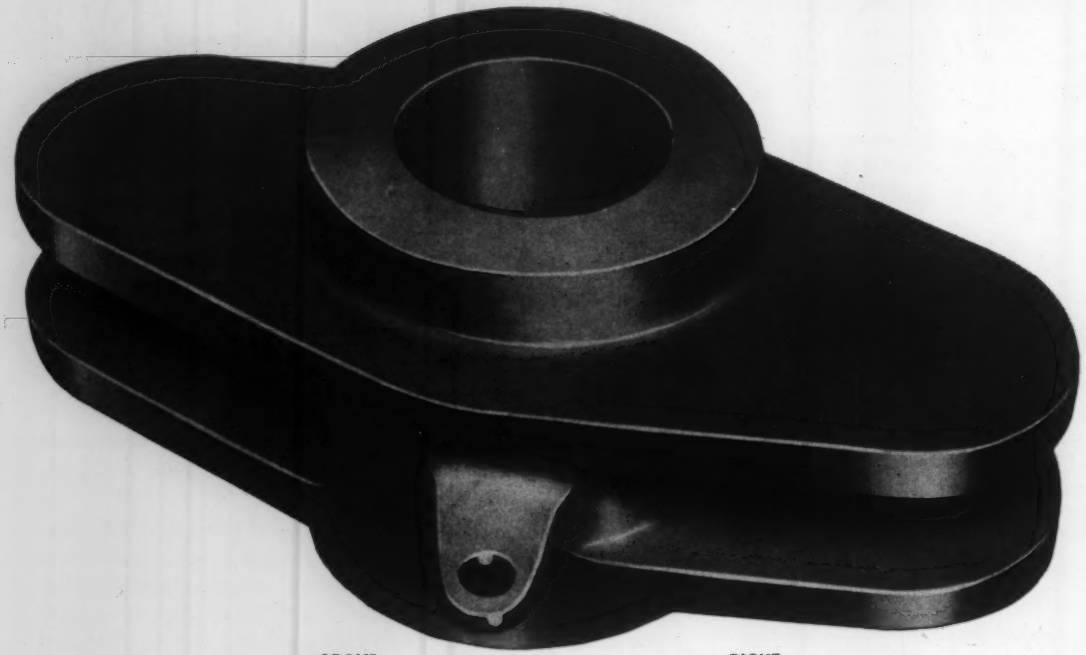
WHEELOCK, LOVEJOY & COMPANY, INC.
134 Sidney St., Cambridge 39, Mass.

AMERICAN STEEL WAREHOUSE ASS'N.

Circle 554 on Page 19

BEFORE YOU SAY . . .

"IT CAN'T BE CAST"



ABOVE:

Automatic Winch brake pawl carrier.

Previous cast weldment required costly machining. ESCO Shellcasting eliminated major machining and effected considerable savings.

RIGHT:

Transmission Shifter Fork.

As formerly cast the fork tip pads posed difficult alignment problems during machining. ESCO Shellcast made possible the casting of the fork tip pads to size and in alignment, eliminated machining, reduced the unit price.

CALL AN ESCO ENGINEER

ESCO alloy steel castings can make your designing *easier.* You get the part you want, in the alloy you need and in the shape that saves you the most fabricating, machining and finishing time.

PLUS METALLURGICAL ENGINEERING AND RESEARCH

ESCO maintains one of the largest and best equipped metallurgical staffs of any alloy steel foundry—

PLUS PRODUCT ENGINEERING AND DESIGN

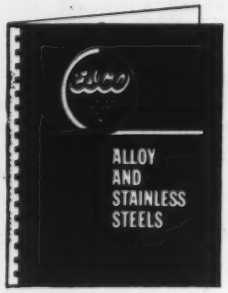
An integrated service at all levels; in the field, at the drawing board and in the foundry—

PLUS FOUNDRY FACILITIES AND CASTING EXPERIENCE

A casting service that covers the complete range of alloy steel casting methods of all applications—

PLUS LABORATORY INSPECTION AND TESTING

ESCO laboratory technicians are qualified and equipped to perform all types of inspections and testing to the most rigid specifications.



Write today for your **FREE** copy of this informative 100-page reference book, "*ESCO* Alloy and Stainless Steels for the Process and Manufacturing Industries"

Call an *ESCO* Engineer—let him show you how *ESCO* Alloy Steel Castings make your designing easier.

ELECTRIC STEEL FOUNDRY COMPANY
2183 N. W. 25TH AVE. • PORTLAND 10, OREGON
MFG. PLANTS AT PORTLAND, ORE. AND DANVILLE, ILL.
Offices in Most Principal Cities
ESCO INTERNATIONAL, NEW YORK, N. Y.
IN CANADA ESCO LIMITED

Giants of American instrument industry, including such firms as . . .

- Bulova Research & Development Laboratories, Inc.
- Eclipse Pioneer, Division of Bendix Aviation Corp.
- Federal Telecommunication Laboratories, Inc.
- General Electric Co.
- Sperry Gyroscope Co.

and many others think of CHATILLON, when instrument design calls for the "world's most accurate spring".

CHATILLON . . . the leading manufacturer of precision springs is particularly proud of the improved performance record of instruments using the noteworthy CHATILLON developed temperature-compensated alloy "Iso-Elastic". The hysteresis error of this remarkable spring is less than .05% of deflection. Drift does not exceed .02% of deflection in 5 minutes. These characteristics plus temperature compensation insure the ultimate in precision spring production.

CHATILLON makes Extension, Spiral, Torsion, Compression and Form Springs of Iso-Elastic material, as well as springs of all conventional alloys.

To find out how "the World's Most Accurate Spring" can better your product and for engineering bulletins, write CHATILLON SPRING DIVISION.

*U.S.A. Pat. No. 2174171

JOHN CHATILLON & SONS
85 CLIFF STREET, NEW YORK 38, N.Y.
Manufacturers of Scales, Force Measuring Instruments and Precision Springs Since 1835

(*Continued from Page 219*)

ing drawings with process or flow-type camera. Half-size positives in turn make excellent diazo prints. Either weight can be used to make enlarged positives from microfilm positives. **Eastman Kodak Co.**, Rochester 4, N. Y. N

Circle 716 on Page 19

DC Power Supply

for voltages of 0 to 32 v dc

Model NFBR filtered dc power supply with less than ¾ per cent ripple at top load is designed for rack mounting. It is for voltages of 0 to 32 v dc with current loads from 0 to 15 amp. Input is 115 v, 50/60 cycles. Unit incorporates germanium rectifiers for increased efficiency. Rack-mounting panel is 10½ in. high x 19 in. wide. Power supply incorporates a heavy-duty transformer and choker. **Electro Products Laboratories Inc.**, 4500 N. Ravenswood Ave., Chicago 40, Ill. I

Circle 717 on Page 19

Magnetic Tape

has long life

C-1 magnetic tape, designed for computer use, has high magnetic properties and long life. Tape has lowest coefficient of friction of any magnetic tape. It rides directly against recording heads without undue wear. Coating formulation produces a magnetic output which is powerful and completely uniform. Moisture-resistant tape shows no change in performance in relative humidities to 100 per cent. Tape is furnished in two thicknesses of Mylar backing. A 1-mil backing provides lengths of 3600 ft; shorter lengths are available with 1.5-mil backing. **Ampex Magnetic Tape**, 934 Charter Ave., Redwood City, Calif. M

Circle 718 on Page 19

THE ENGINEER'S

Library

Recent Books

Engineering Manual. *Edited by Robert H. Perry, associate professor of chemical engineering, University of Oklahoma; 652 pages, 5 by 7½ in., clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, *$9.50 per copy postpaid.*

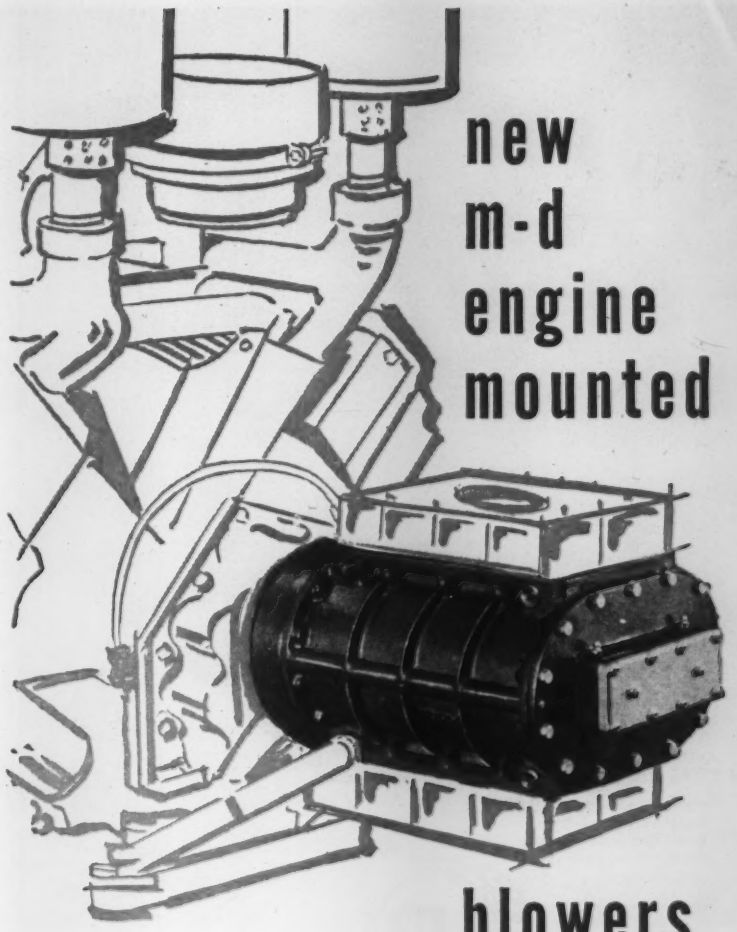
Formulas, data, and methods commonly used in the fields of chemical, electrical, mechanical, civil, architectural, and nuclear engineering are collected in this manual. Three introductory sections present mathematics, mathematical tables, and physical and chemical data common to all engineering computations. Electrical section discusses ac and dc circuit theory, transients, rectifiers, transformers, and motors and generators. Mechanics, thermodynamics, fluid mechanics, pumps, and machine design are covered under mechanical engineering.

Principles of Mechanics. *By John L. Synge, senior professor, School of Theoretical Physics, Dublin Institute for Advanced Studies, and Byron A. Griffith; 552 pages, 6 by 9 in., clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, *$9.50 per copy postpaid.*

Containing three sections, this third edition first covers plane statics and dynamics. Vectors are used extensively in discussing mechanics in space, a more advanced section which is complete in itself. The last part discusses general mathematical methods, vibrations, and relativity. Major revisions include new chapters devoted to Lagrange and Hamilton equations, changes in notation to agree with current U. S. usage, and additions to the number of exercises and problems.

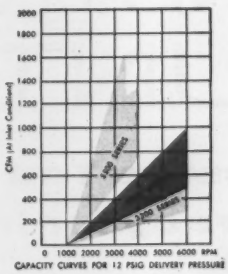
Metal Fatigue. *Edited by George Sines, associate professor of engineering, University of California, and J. L. Waisman;* 415

(Please turn to Page 226)



new m-d engine mounted blowers

weigh only 625 lbs. Provide 400 SCFM continuous air flow



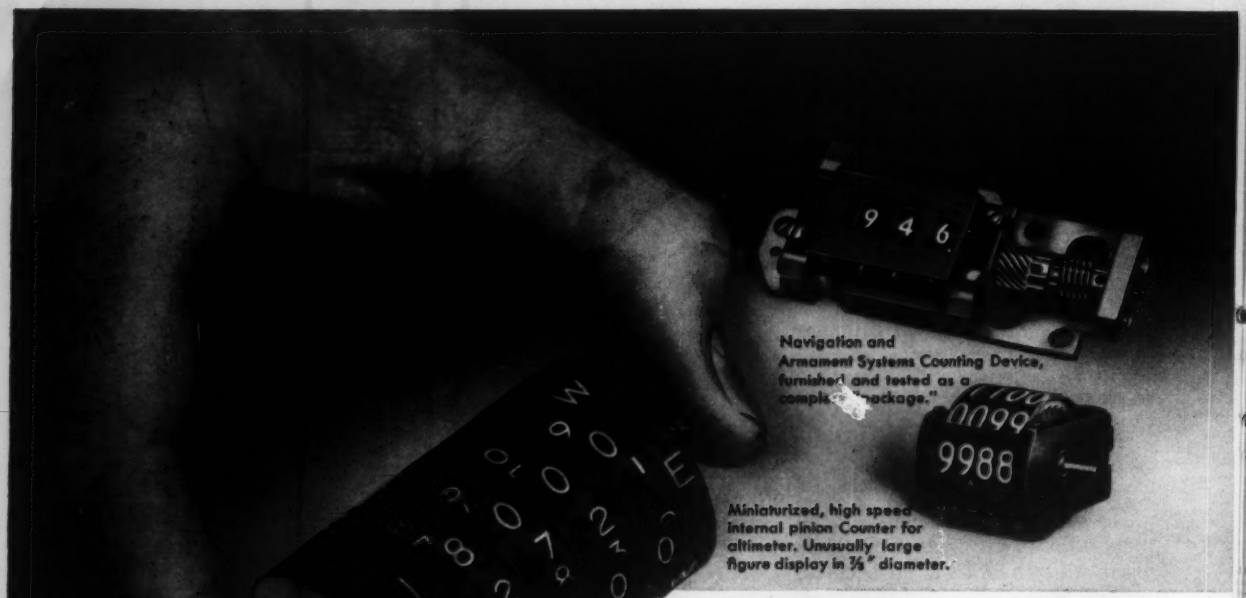
M-D answers the need for lightweight pneumatic units for vacuum or high pressure systems. Only 625 lbs. total weight of blower *and* engine. Dependable M-D units generate 15 PSIG of continuous air flow or up to 18 PSIG in surges. Ideal for mobile applications. M-D muffler packs mean quiet operation.

M-D blowers operate at wider pressure and speed ranges than any other rotary positive blower. Capacities of 22 production models range from 50 to 4,000 CFM, pressures to 15 PSIG single, 70 PSIG multi-stage.

For full information write

M-D BLOWERS, INC., RACINE, WISCONSIN

A SUBSIDIARY OF MIEHLE-GOSS-DEXTER, INC.



Navigation and Armament Systems Counting Device, furnished and tested as a complete package.

Miniaturized, high speed internal pinion Counter for altimeter. Unusually large figure display in 3/8" diameter.

Navigational Counter designed with concentric drums for maximum figure display in minimum space.

VR 9-43

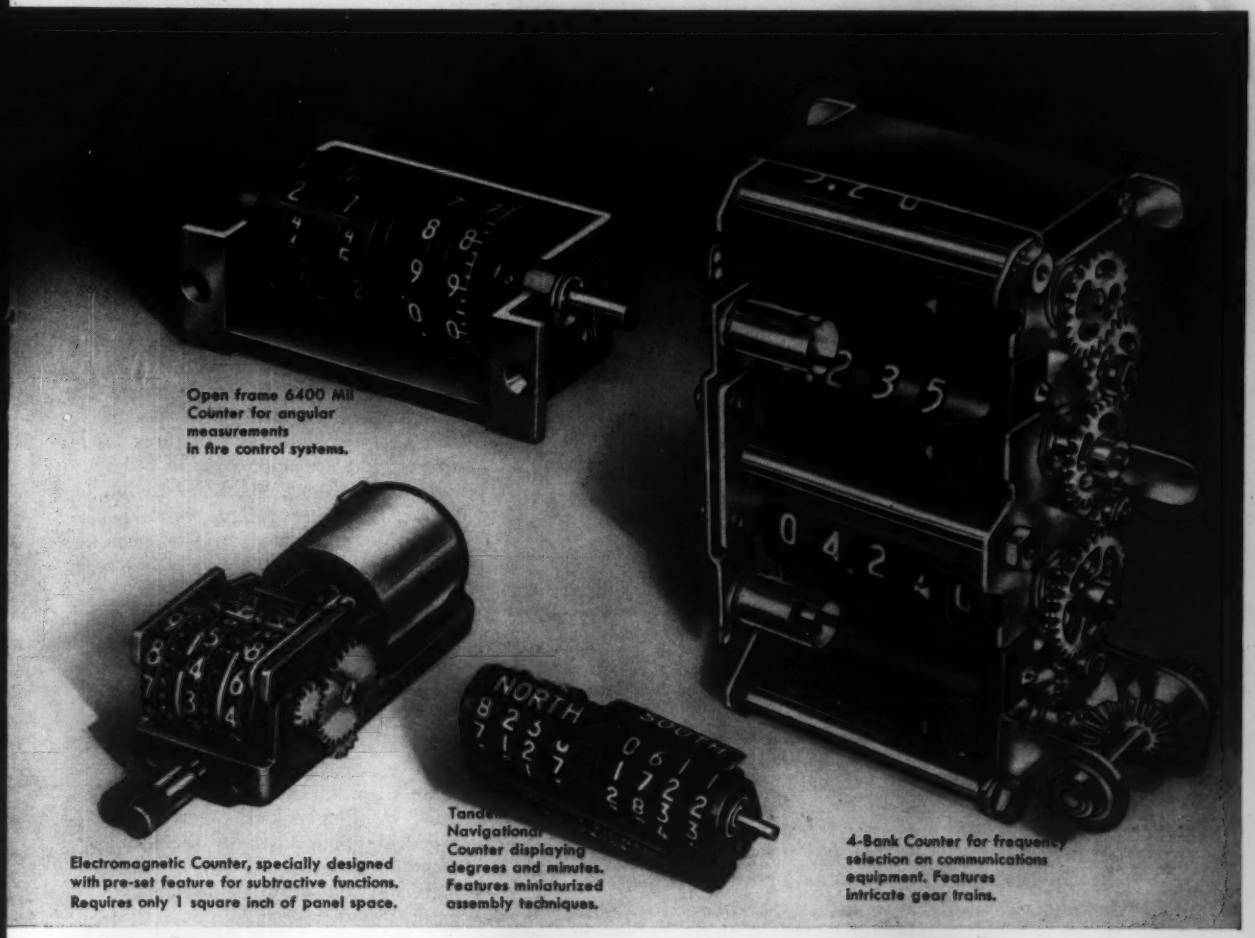
VR PRECISION INSTRUMENT COUNTERS

Assure Top Reliability and Accuracy for Instrumentation

Veeder-Root's long experience in the design, development and production of intricate, miniaturized counting devices gives you that extra margin of dependability whenever instrumentation requires digital readout. In fact, Veeder-Root makes the most extensive and varied line of instrument-type counters in the world!

There's another Veeder-Root specialty of importance, too — application ingenuity. Whatever your instrument problem or requirement,

Make Instruments Do More With These Veeder-Root Counter Types: PREDETERMINED • ELECTRONIC • MAGNETIC



Open frame 6400 Mil Counter for angular measurements in fire control systems.

Electromagnetic Counter, specially designed with pre-set feature for subtractive functions. Requires only 1 square inch of panel space.

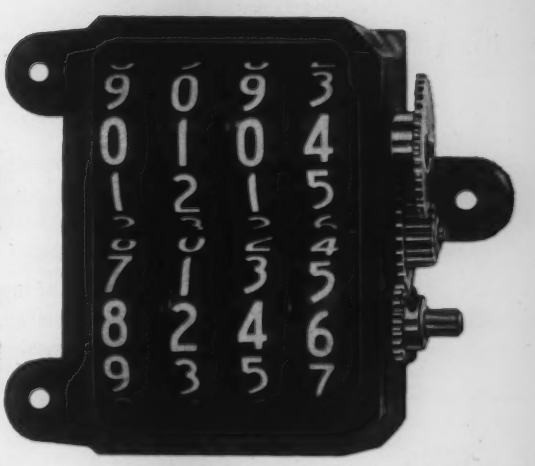
Tande... Navigational... Counter displaying degrees and minutes. Features miniaturized assembly techniques.

4-Bank Counter for frequency selection on communications equipment. Features intricate gear trains.

Veeder-Root can provide the answer by supplying a single device or a complete counting "package" to fit your system.

The Veeder-Root Counters shown here are only a small selection of the specialized line of precision counters developed for instrument and military applications. Each demonstrates Veeder-Root's ability to design and produce to high precision, fine tolerances, and military specifications, and to satisfy severe environmental testing requirements.

Send Us Your Requirements Now . . . Take full advantage of Veeder-Root's extensive Counter know-how to help improve the accuracy and reliability of your instrumentation or system. Contact your local Veeder-Root Counting Engineer or write direct.



Dual Counter device for communications equipment. Features intricate assembly and gearing.

Veeder-Root INC.

Hartford 2, Connecticut

'The Name that Counts'

Hartford, Conn. • Greenville, S. C. • Altoona, Pa. • Chicago • New York • Los Angeles
San Francisco • Montreal • *Offices and Agents in Principal Cities*

• GEAR DRIVEN • AUTOMATIC RESET • REMOTE DATA READOUT • COUNT-PAKS • REVOLUTION • DEGREE

CAREER OPPORTUNITIES AT TI

A typical mechanization project . . . TI-designed Automatic Wafer Sorter. Machine automatically classifies semiconductor wafers in 1/10-mil increments.

MECHANIZATION ENGINEER

your future: a challenging opportunity with an industry leader

Accelerate your professional growth by joining one of Texas Instruments most important operations....the mechanization of semiconductor manufacturing equipment!

Work with or lead a mechanization team of top talent with advanced facilities. Specific and rewarding assignments include the design and test of production and prototype equipment on a problem-solving basis, and you will materially contribute to TI's record of engineering and manufacturing achievements.

Advanced personnel policies include company-paid profit sharing (last year 15% of base salary) . . . and premium living is furnished by Dallas' climate and excellent neighborhoods, schools and shopping facilities.

These jobs require a high degree of mechanical aptitude and at least three years' work in design of manufacturing equipment for precision components.

Interviews will be held in your area soon.
Please send a resume immediately to:

C. A. BESIO
Dept. 203

TEXAS INSTRUMENTS
INCORPORATED
SEMICONDUCTOR-COMPONENTS DIVISION
13500 N. CENTRAL EXPRESSWAY
POST OFFICE BOX 312 • DALLAS, TEXAS

(*Continued from Page 223*)

pages, 6 by 9 in., clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York 36, N. Y.; available from MACHINE DESIGN, *$12.50 per copy postpaid.*

Dissemination of latest concepts and techniques dealing with metal stress and fatigue is the aim of this collection of material. Fatigue strength, failure mechanisms, and appearance of fracture surfaces are discussed. Metal testing methods and analysis of test data are described. Several sections deal with design and analysis of metal structures in aircraft but are applicable to other types of machines. Notch sensitivity, high-temperature fatigue, and fatigue life of welded, riveted, and bolted assemblies are also covered.

How To Increase Your Creative Output. *22 pages, 8½ by 11 in., paperbound, stapled; published by and available from Industrial Relations News, 230 West 41st St., New York 36, N. Y.; $1.50 per copy.*

Procedures used by numerous creative scientists and engineers assume a general over-all pattern outlined in this booklet. A series of practical guide-posts for increasing creative output is also listed. These methods and hints help eliminate painful and time-consuming trial-and-error in problem solution and permit an effective creative process to progress rapidly.

New Standards

American Standard Y15.1-1959, Illustrations for Publication and Projection. *14 pages, 8½ by 11 in., paperbound, stapled; published by and available from The American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.; $2.00 per copy.*

Standard methods are described for preparing graphs, line drawings, and tabular illustrations for technical publications and slide projection. Simplicity, legibility, and unity are emphasized and illustrated with practical guide rules. A new, integrated system uses a standard drafting form for preparing effective designs while saving production time and expense. Sizes for ordinary template lettering, symbols, and ruled lines are established. Directions for lettering with modern electric typewriters are included.

Now...in handy, concise form

Design Data and Application Hints on J-M Moulded Packings

Here's a "must" for your reference file—Johns-Manville's helpful, new Moulded Packings brochure. Designed to offer you complete engineering details on packings for hydraulic and pneumatic applications in handy, condensed form, this booklet is packed with the data you need most at every stage of planning and design.

In this compact handbook you'll find data on Johns-Manville Packings for pistons and rods—including cups, Uneepac® Rings, V-Rings and Sea® Rings, Cumpac®, and Conepac. Data on pressure and temperature ranges and information on packing materials are also included.

Easy-to-read drawings show you complete packing and stuffing box details and information on follower ring designs. Operating characteristics and required accessories are spelled out to assist you in evaluating each packing for your application.

MAIL COUPON TODAY for your free copy of this informative brochure.

Johns-Manville, Box 14, New York, N.Y.
Please send me your new, free brochure on Moulded Packings, PK-126A.

Name_____
Title_____
Company_____
Address_____
City_____
Zone_____ State_____

JOHNS-MANVILLE

JOHNS-MANVILLE JM PRODUCTS

Circle 560 on Page 19

Wanted: Engineers

with an interest in writing

Like to break into an interesting field where you'll make good use of your engineering talents — yet have a chance to develop new skills?

We're looking for several men with engineering experience and a yearning to write or edit. As an editor on MACHINE DESIGN, you would broaden your engineering background in a job that provides stimulating contact with people in many engineering areas.

You don't have to have actual writing or editing job experience, although we expect definite ability in handling the English language. An ME or EE degree plus several years of design-engineering experience would be ideal, but we'll be happy to consider equivalent qualifications. Age: 25 to 35.

If you've worked in a design-engineering specialty area, we'd like to hear about it. We're interested in any job experience or training in:

- Mechanical drives, controls, systems
- Mechanical components, assemblies
- Electrical or electronic drives, controls, systems
- Hydraulic or pneumatic systems, drives, controls
- Materials and finishes selection or specification
- Design for manufacture or production design

Our headquarters are in Cleveland. There is opportunity for travel to engineering meetings, expositions, and manufacturing companies. Salary will depend on your background and experience.

If you are interested, send a resume of your engineering background, and any evidence you may have of writing ability (we'll return this if you wish) to: Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

MACHINE DESIGN

For complete chain drives ¼" to 2" pitch . . .

BOSTON Gear SPROCKETS and CHAIN

FROM STOCK . . . at Factory Prices

Catalog No. 57 lists

ANY TYPE OR SIZE YOU NEED

.81" to 50.94" P.D. SPROCKETS, iron and steel, for single ROLLER CHAIN

1.92" to 26.74" P.D. SPROCKETS, iron and steel, for double ROLLER CHAIN

¼" to 2½" P. ROLLER CHAIN single, double, and triple strand

DOUBLE PITCH ROLLER CHAIN
1", 1¼", 1½" P. Drive Series
1", 1¼", 1½", 2" P. Conveyor Series
1", 1¼", 1½", P. Agricultural Series

1.94" to 12.74" P.D. SPROCKETS, iron and steel, for BLOCK CHAIN
⅛" to ½" w. BLOCK CHAIN

.37" to 6.07" P.D. SPROCKETS, bronze and steel, for LADDER CHAIN
.185" to .353" P. LADDER CHAIN brass and steel

Save machining time

SHOLD-A-GRIP interchangeable tapered SPROCKETS and BUSHINGS
2.09" to 23.88" P.D. SPROCKETS adaptable with tapered BUSHINGS to shaft sizes ½" to 3" by 16ths

BORED-TO-SIZE ready-to-install SPROCKET PINIONS
Complete with keyway and setscrew. ⅜" through 1" P., in 86 tooth sizes, with 360 stock bores

Order from your local Distributor. You save time and expense — you get BOSTON Gear top-rated quality and lasting economy. Be cost-wise — standardize. Boston Gear Works, 64 Hayward St., Quincy 71, Mass.

CALL YOUR NEARBY
BOSTON Gear®
DISTRIBUTOR
— STANDARDIZATION PAYS —®

For nearest Distributor LOOK UNDER "GEARS" in the "Yellow Pages"

9496 "OFF-THE-SHELF" TRANSMISSION PRODUCTS FROM STOCK — AT FACTORY PRICES — ASK FOR CATALOG
Stock Gears • Sprockets and Chain • Speed Reducers • Bearings • Pillow Blocks • Couplings

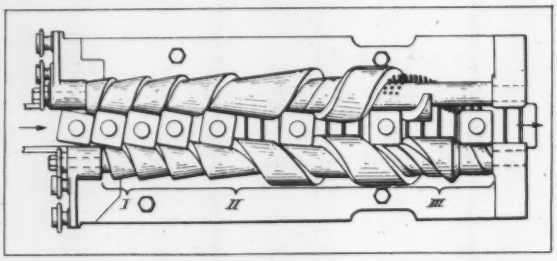
Who but
Atlantic
Casting?
This cast aluminum chassis protects vital electronic circuitry made for ATLAS by the General Electric Company.
How
but with Atlantic's plaster mold casting could these requirements be met?
▶ SIZE: 13" x 6½" x 2" (overall) with .10" walls.
▶ SURFACE: 125 microinches max. (as cast)
▶ TOLERANCES: ± .005 or less (as cast)
▶ DRAFT: Outside wall, 0° Inside compartments, ½°
▶ FLATNESS: .010 (overall)
▶ WITHOUT FLAWS: (checked by X-Ray)
Tolerances are too close and overall size too large to be economical by investment casting. Surface finish and tolerances are too tight for sand or permanent mold casting.
Quantity is too small and soundness too critical for Die Casting.
PHONE OR WRITE for Specific Information on Economical Aluminum Castings to Critical Specs
New Catalogs Now Available On Request.
ATLANTIC
CASTING and ENGINEERING CORP.
810 Bloomfield Avenue • Clifton, N. J.
PRescott 9-2450

NOTEWORTHY

Patents

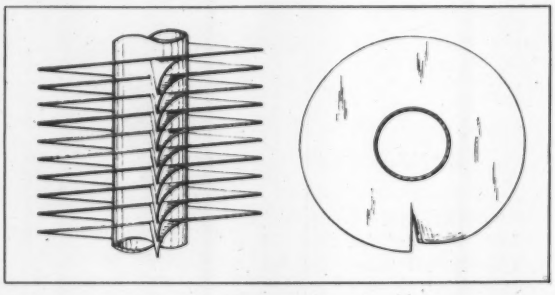
Spiral Drive and Positioning Mechanism

A pair of matched spiral cams grip a number of identical articles positively, orient them with respect to their direction of travel, and carry them at desired speeds and accelerations past processing stations. The cams can be made in lengths each having constant characteristics, then assembled coaxially to provide desired patterns of motion. In this example, section I drives at slow constant speed and cants the articles 10 deg, section II accelerates the articles, and section III drives articles at fast constant speed. Opposite cam rotation tends to hold articles on their horizontal support surfaces. *Patent 2,890,787 assigned to Geo. J. Meyer Mfg. Co., Cudahy, Wis., by Sidney T. Carter.*



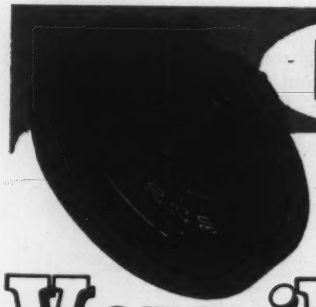
Heat-Exchanger Fins

Condensate formed on the fins of a heat exchanger is drained by gravity down a path of slots cut in the outer edges of the fins. Efficient removal of condensate prevents freezing of condensate and consequent reduction of performance. *Patent 2,896,426 assigned to Carrier Corp., Syracuse, N. Y., by Robert W. Ayling.*



Adjustable-Stroke Linear-Motion Transmission

In a magnetic-fluid mechanism, cyclic thrust input, as from a cam, can be transmitted to output at fractions of input frequency or intermittently according to the arrangement of electrical switch control. With



NEW!

COLORFUL, LOW COST, PRECISION SHAFT TURNS COUNTER

VerniDial

The VerniDial H5850 is a lightweight, reliable and economical turns counter for accurately positioning multi-turn devices such as potentiometers, capacitors, valves and other equipment where micrometer readout of a setting is desired. Graduated in hundredths, it accumulates to 20 turns... reading or positioning from zero to 2000/100.

7 Colors (solid or combinations!): Black, Gray, Off-white, Yellow, Orange, Red, Green.

RESISTS CORROSION

INSULATES CIRCUITRY and BODY CAPACITY

COLORFUL for CODING and DESIGN

LIGHT WEIGHT MOLDED PLASTIC

EASILY INSTALLED

Write for Bulletin H5850

HOWELL INSTRUMENT COMPANY
3101 Trinity Street, Fort Worth 7, Texas

Circle 563 on Page 19

EVERY ANSWER TO SPEED REDUCER and GEAR REQUIREMENTS

SPEED REDUCERS...

Get this pocket-size Manual-Catalog..... Spur, worm, combination, single and double reduction types. 1/50 to over 400 hp. —ratios to 10,000 to 1.

GEARS...

Get this handy Bulletin.. Custom-cut in any type or material—any quantity. 96 to 5/7 D.P.—¼" to 18" P.D. Complete gear trains.

Available now from
Send your requirements for prompt quotation

Abart

ABART GEAR and MACHINE CO.
4821 WEST 16th STREET • CHICAGO 50, ILLINOIS

Circle 564 on Page 19

SOUTHWEST

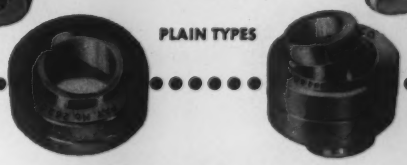
"Monoball"

SELF-ALIGNING BEARINGS

ROD END TYPES

PATENTED U.S.A.
All World Rights Reserved

PLAIN TYPES



CHARACTERISTICS

	ANALYSIS	RECOMMENDED USE
1	Stainless Steel Ball and Race	For types operating under high temperature (800-1200 degrees F.).
2	Chrome Alloy Steel Ball and Race	For types operating under high radial ultimate loads (3000-893,000 lbs.).
3	Bronze Race and Chrome Steel Ball	For types operating under normal loads with minimum friction requirements.

Thousands in use. Backed by years of service life. Wide variety of Plain Types in bore sizes 3/16" to 6" Dia. Rod end types in similar size range with externally or internally threaded shanks. Our Engineers welcome an opportunity of studying individual requirements and prescribing a type or types which will serve under your demanding conditions. Southwest can design special types to fit individual specifications. As a result of thorough study of different operating conditions, various steel alloys have been used to meet specific needs. Write for Engineering Manual No. 551. Address Dept. MD-M59

SOUTHWEST PRODUCTS CO.
1705 SO. MOUNTAIN AVE., MONROVIA, CALIFORNIA

Circle 565 on Page 19

NEW!

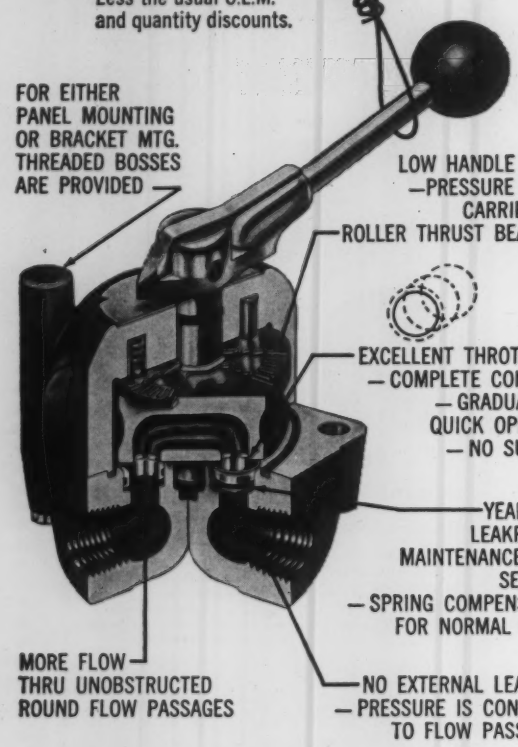
A "SHEAR-SEAL" VALVE

for LESS than a spool valve

RATED FOR 3000 P.S.I. OIL SYSTEMS

$65.00
List Price*
for a ¾" valve

*Less the usual O.E.M. and quantity discounts.


FOR EITHER PANEL MOUNTING OR BRACKET MTG. THREADED BOSSES ARE PROVIDED
LOW HANDLE LOAD —PRESSURE LOAD CARRIED BY ROLLER THRUST BEARING
EXCELLENT THROTTLING — COMPLETE CONTROL — GRADUAL OR QUICK OPENING — NO SURGES
YEARS OF LEAKPROOF MAINTENANCE-FREE SERVICE — SPRING COMPENSATES FOR NORMAL WEAR
MORE FLOW THRU UNOBSTRUCTED ROUND FLOW PASSAGES
NO EXTERNAL LEAKAGE — PRESSURE IS CONFINED TO FLOW PASSAGES

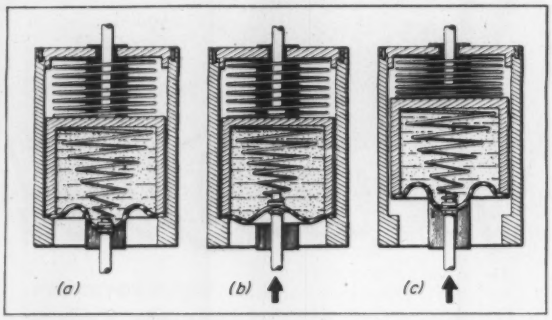
For complete data on this new valve and for information on all your valve requirements write for Catalog V-59-60

CONTROL VALVE DIVISION

Barksdale valves

5125 ALCOA AVENUE • LOS ANGELES 58 • CALIFORNIA

power off, *b*, a driving rod displaces magnetic fluid, distends a diaphragm, and compresses a conical spring, but there is no output. Power turned on, *c*, solidifies



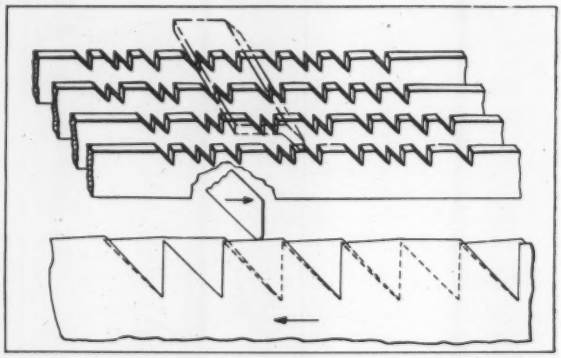
the working fluid which enables output displacement. Power is usually applied at the position of rest, *a*, but can be applied at other times to adjust length of output stroke. *Patent 2,896,456 assigned to International Business Machines Corp., New York, by Jacob J. Hagopian.*

Counterlevered Band Clamp

In a split-sleeve clamp assembly, built-in levers radially outward of the bolt compensate undesirable leverage caused by lips which grip the sleeve ends. Without this compensation, leverage creates a bending moment which opposes tightening of the bolt and causes irregular gripping pressure around the sleeve. *Patent 2,897,568 assigned to Dresser Industries Inc., Dallas, Pa., by Howard L. Hoke.*

Mechanical Sorting Pawl

Functional members in a sorting mechanism are a number of bars or discs, all parallel but each having a distinctive pattern of notches. Each of these members



is movable relative to the others. A toothed pawl scans them to find a position in which notches are aligned. Between notches, lands are canted outward or upward so that the pawl will not snag in a wrong position. The pawl functions properly despite wear of its leading edge. *Patent 2,895,337 assigned to Toledo Scale Corp., Toledo, Ohio, by Walter G. Moring Jr. and Geoffrey T. Gray.*

MA59
MINIATURIZATION AWARD

You are cordially invited to enter the Third Annual Miniaturization Award competition. The Award was established to give national recognition to a company, individual or organization for outstanding achievements in the field of miniaturization. The Award for 1959 will be presented in the spring of 1960. Certificates of excellence will be awarded ten additional outstanding entries. Entries must be received by January 20th. For complete details of the competition, write Miniaturization Awards Committee, Box 604, Keene, N. H.

Circle 567 on Page 19

REDUCE *costs...*
INCREASE *product quality...*
WITH
DRIV-LOK PINS

STANDARD TYPES

A
A3
B
C
D
E
G
U

Type E . . . T Handle for valve

Type U . . . Pinning V Pulley to shaft

- **Fast installation . . . drill a hole and drive it in**
- **Greater holding power . . . once installed they *stay in***
- **Solid body . . . greater strength, better appearance**

DRIV-LOK Grooved Fasteners have been proven in thousands of applications . . . are saving time and labor wherever they're used. 8 standard types — many specials. Wide variety of materials. Prompt deliveries, competitive prices. Write us, giving the nature of your fastening application. We'll recommend and send samples. No obligation, of course. Write for complete Driv-Lok Catalog

DRIV-LOK SALES CORPORATION
715 Park Avenue • Sycamore, Illinois

Circle 568 on Page 19

Need a motor that thrives on "gook"?

If your product must work with motor submersed in "gook" liquids, we'll *customize* a corrosion-resistant motor that performs flawlessly under sewage, oil, chemicals, salt spray, or what have you.

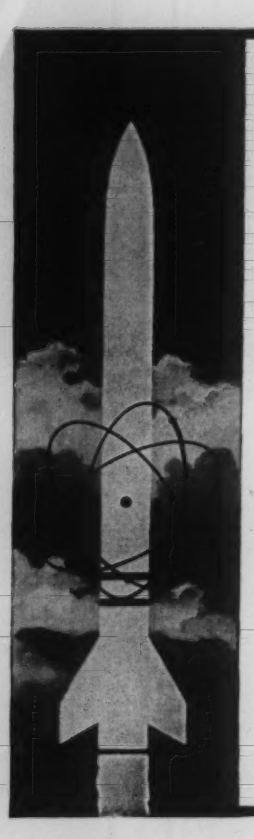
Right now many a J & H motor is powering gas and sewage pumps under the "gookiest" conditions.

If your motor environment, on the other hand, is high temperature, high humidity, fungus or dust, we'll develop a design that solves that problem. What's more, we'll customize it to your product, provide the torque characteristics you want, the size and shape you need.

You set the situation or condition—leave the rest to J & H. Our range is ⅓ through 5 hp, up to 15 hp for submersibles. Call us.

JACK & HEINTZ, Inc.
COMMERCIAL MOTOR DIVISION
17625 Broadway • Cleveland 1, Ohio

Circle 569 on Page 19



Aid for Technological Pioneers

in the fields of Missiles and Aircraft Electronics, Nuclear Energy

MAGNESIUM-THORIUM This lightweight material has creep resistance and good yield strength at elevated temperatures. B&P produces rolled HK-31 sheet and specializes in HK-31 assemblies for missile and electronic applications.

ELECTROPLATING OF MAGNESIUM Ideally suited to a wide range of electronic applications, electroplated Magnesium is easily soldered. B&P plates Magnesium with copper, tin, nickel, chromium, silver and gold to your requirements.

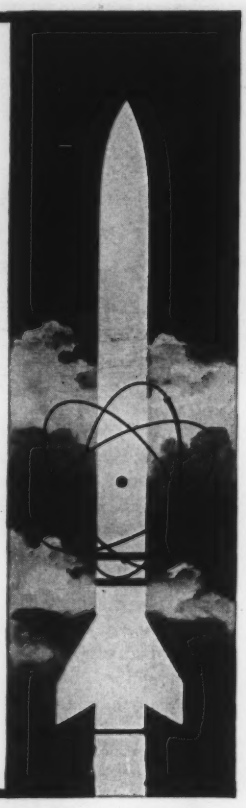
BORAL The first commercial source of Boral, B&P is equipped to supply assemblies as well as Boral plate in any concentration of boron carbide required for nuclear reactor use and other applications.

TITANIUM Using its techniques developed for Magnesium, B&P produces unusually deep draws in Titanium with a single stroke of the press. B&P also stretch forms, press-brake forms and welds Titanium fabrications.

FREE DATA BOOK on Magnesium and Titanium. Comprehensive, illustrated, physical properties, design data, etc. Write on your letterhead to:

BROOKS & PERKINS, INC.
1940 WEST FORT ST., DETROIT 16, MICH.
TASHMOO 5-5900

68-T-1



Circle 570 on Page 19

YOU KNOW YOU WOULDN'T RACE THIS at DAYTONA BEACH...
BUT WHAT DO YOU KNOW ABOUT
AIR CYLINDERS?
NEW CATALOG AVAILABLE
Write Before Next Tuesday

MD-9

ALLENAIR CORP. 255 EAST 2nd ST., MINEOLA, N. Y.

Name.....

Company.....

Address.....

City.....Zone.....State.....

FUNK SAVED MONEY FOR THIS COMPANY

On this Dart "Mine Buggy" a compactly-designed Funk transmission provides multiple speed control and doubles as a drop box, thus saving the cost of a 3-stage gear box or a fixed chain drive.

And a Funk Revers-O-Matic Drive, equipped with torque converter, allows the buggy operator to change direction of travel with foot lever only.

Another example of how FUNK MODULAR POWER UNITS can be economically combined — in an unlimited number of arrangements.

Let FUNK solve *your* power transmission problem.

FUNK MFG. CO. Box 577-F Coffeyville, Kans.

Circle 571 on Page 19

Circle 572 on Page 19

GEARMOTORS

5 Basic Sizes

- Speed up to 200 RPM
- Power up to 40 in. lb.
- Open or enclosed case
- Continuous or intermittent
- Machine cut gears
- Finish ground shafts
- Special features available
- Millions in use
- Prompt delivery
- Samples at once
- Ask for our literature

Motoresearch also designs and produces high frequency motors, generators, rectifier type power supplies and other Special Electrical Equipment. We invite your inquiries.

OPEN TYPE MOTOR

Millions of Motoresearch Gearmotors now in use!

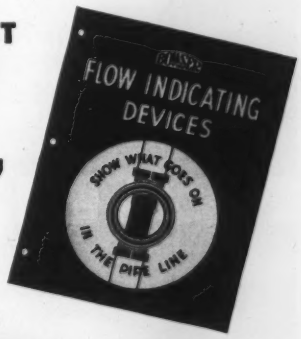
MOTORESEARCH COMPANY

1600 JUNCTION AVENUE
RACINE, WISCONSIN

Designers and Manufacturers of
SPECIAL ELECTRICAL EQUIPMENT

Circle 573 on Page 19

THIS BOOKLET "FLOW INDICATING DEVICES" IS YOURS



... CONTAINS DATA ON WIDE SELECTION OF FLOW DEVICES SUCH AS:

Fig. 54A
Flow Sight

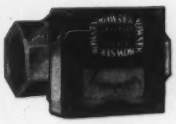


Fig. 816
Teleflo Indicator

Fig. 811
Flow Indicator

Plant and product engineers have relied on Bowser, liquid handling specialists since 1885, for prompt service. For sight glasses in single or double-window types, gravity or pressure models; or for electric or mechanical indicators . . . and a full line of sight feed oilers.

PRODUCT RESEARCH — BOWSER

WRITE FOR FLOW DEVICES BOOKLET } *Contains Complete Specifications*

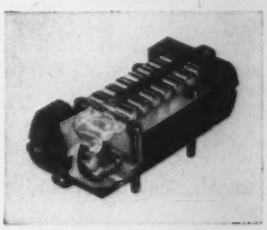
BOWSER, INC., MARKETING DIVISION, FT. WAYNE, IND.

Circle 574 on Page 19

Now... increase accuracy, sensitivity, and rigidity of your machine tools

with Scully-Jones Tychoway recirculating roller bearings

Use of these new antifriction way bearings in tables, columns, tailstocks, carriages, and spindles of machine tools can increase both capacity and accuracy—open the door to greater versatility by solving



friction, lubrication, gibbing, and feed problems in a new and more practical manner.

By putting all or part of the column or table load on bearings, you can equalize starting and running friction, maintain a constant ratio between running friction and velocity, eliminate fishtailing, and reduce power requirements. Think of the increased sensitivity to error, the ease of manual positioning, and the new possibilities for automatic control.

The same principle can be applied to spindle heads. Tychoway bearings permit accurate alignment without upper and lower surface parallelism. This means rigidity and weight needed for heavy machining can be combined with great sensitivity.

Tychoway bearings meet every standard of the machine tool industry. All working parts are made of through-hardened 52100 bearing steel. Precision rollers circulate through a return channel within the race. Your machine way serves as the other race. Bearings may be spring-loaded and used in combination with opposed fixed bearings. They reduce machine wear, eliminate hand fitting, simplify lubrication.

EXAMPLE: Eight Tychoway bearings are used in this spindle head saddle of the Kearney & Trecker Milwaukee-Matic. Positive preload bearings serve the dual function of reducing friction and guiding the head.

Accuracy of alignment is ± .0002 in. Four spring-loaded bearings carry one-third the weight of the 10,000 lb column, which repeats positioning accuracy within .0001 in. Write for Bulletin 22-50.

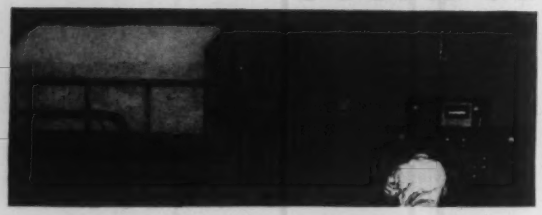
SCULLY JONES

Scully-Jones and Company
1905 S. Rockwell St., Chicago 8, Ill.

Circle 575 on Page 19

CONFIDENCE

where control



counts

Temperature Controls for Industrial, Aircraft, Marine, Special Purpose

APPLICATIONS: Unlimited. For 28 years, we have been designing and manufacturing controls to fit individual needs.

MEDIUM: Air, liquid or hotplate.

RANGE: −150 to +650°F, adjustable.

SENSITIVITY: ±.5°F and up.

SWITCHES: Normally closed, open or double throw. Manual reset, high ambient and others available. 15 or 20 amps. 115/250 Volts AC. Also DC.

TYPES: Local mounted, remote bulb, skeleton or enclosed, calibrated or uncalibrated, single or multi-switch, indicating, explosion-proof, minimum size and special purpose.

OPERATION: Precision-made, liquid filled bellows combine with full rated snap-action switches for quick, accurate response to temperature change.

For further information request Condensed Catalog #400.

UNITED ELECTRIC

UE

CONTROLS COMPANY

88 School St., Watertown, Mass.

FHP motors... engineered especially for your product

The new RAE M-40 Series, in 3 ratings at 5000 RPM. AC/DC Universal or DC Shunt. M-41 and M-42 rated ½ H.P. M-43 and M-44 rated ¾ H.P. M-45 and M-46 rated 1 H.P. Available with any of Rae's gear units.

RAE motors

RAE engineers are recognized specialists in solving difficult FHP motor applications. By careful analysis and testing of your product, they can save you time and money in selecting the right motor.

RAE offers outstanding service and quality in a large variety of motors. Available in voltages up to 250, and up to 1/2 H.P. (higher for intermittent duty) with many gearhead motor combinations.

Find out how RAE motors can *improve your product* and *reduce costs* as they are doing for other leading manufacturers.

*Send for the "RAE" Engineering Data Sheet. It will help you supply the data necessary for recommendations and prices.

Rae MOTOR CORP.

2009 Kewaunee Street
Racine, Wisconsin

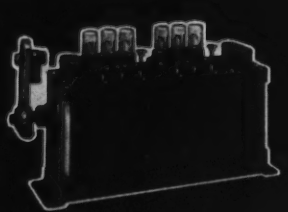
AC/DC Universal • DC Shunt Wound • DC Series Wound • Gear Reduction Motors • Governor Controlled Motors • Motors for Rheostat Control • Motors for Electronic Control • Permanent Magnet Motors and Gearmotors.

Circle 577 on Page 19

accurate...
controlled...
timed lubrication... by

MANZEL

• Wide range of lubricators and controls, in single and multi-feed units. Experienced field engineers at your service to solve any problem.



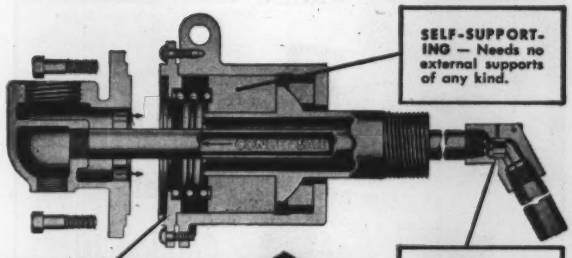
HOUDAILLE Manzel

276 Babcock Street
Buffalo 10, N. Y.

Specialists in metering pumps and lubricators since 1898

Circle 576 on Page 19

Circle 578 on Page 19


SELF-SUPPORTING — Needs no external supports of any kind.
ASSEMBLY PLATE — Holds internal parts in position when head is removed.
SYPHON ELBOW — Permits use of straight pipe for syphon. Can be inserted or withdrawn right through the joint.

Johnson Rotary Joint with SYPHON ELBOW

Johnson Joints represent the best way industry has yet found to get steam or liquids into rotating rolls and cylinders. They are completely packless, need no lubrication or adjustment. The Type SBP shown gets steam in, condensate out, through the same head. Other types available for through flow service, in sizes to meet all operating needs. ***WRITE FOR COMPLETE INFORMATION.***

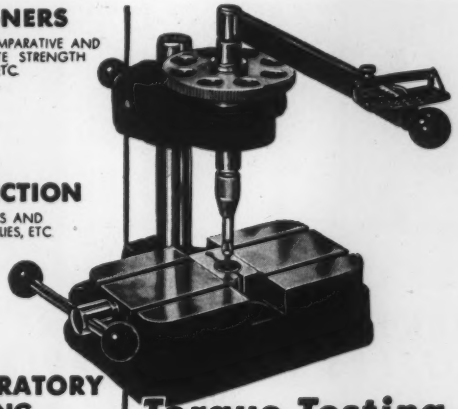
The Johnson Corporation

811 Wood St., Three Rivers, Mich.

Circle 579 on Page 19

DESIGNERS
for COMPARATIVE AND ULTIMATE STRENGTH TESTS, ETC.

INSPECTION
of PARTS AND ASSEMBLIES, ETC.



LABORATORY TESTING
of SCREWS
SOCKETS
TAPS
LOCK NUTS
DRIVING BITS
HAIR SPRINGS, ETC.

PRODUCTION QUALITY CONTROL
for DELICATE OPERATIONS, ASSEMBLY OF FRAGILE MECHANISMS OR INSTRUMENTS; FOR FASTENERS IN PLASTICS AND LIGHT METALS.

Torque Testing FIXTURE

A universal fixture with 1000 uses. Holds driver in accurate alignment; in instrument bearings. Provides rapid engagement with test sample...torque is applied and measured with Sturtevant Torque Wrench.

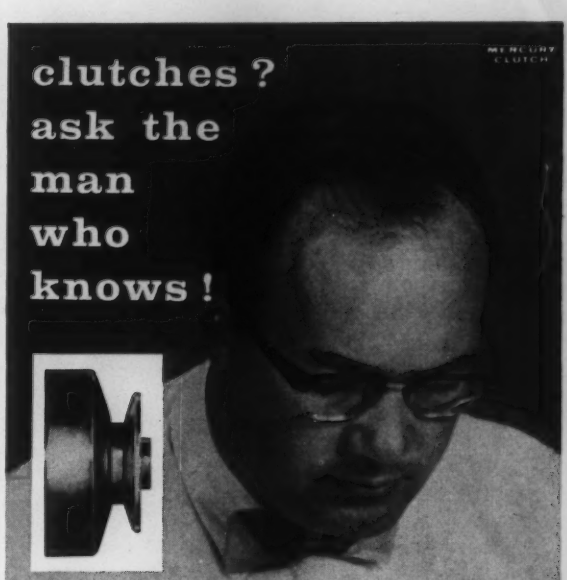
Model TTF¼ *Capacity* 0-200 in. lbs.
Model TTF½ *Capacity* 0-150 ft. lbs.

Write for Bulletin TF

PA STURTEVANT CO.
ADDISON QUALITY ILLINOIS

Circle 580 on Page 19

clutches? ask the man who knows!



Ask a Mercury engineer; he knows clutches. Clutches are his sole stock-in-trade . . . not a sideline. From among Mercury's complete line of precision-built, standard automatic clutches (with exclusive MercoTorque action), or from over 5,000 configurations, he will come up with the perfect clutch for your job. "It's always a better design when it's drawn around a dependable Mercury Automatic Clutch." Call in a Mercury engineer.

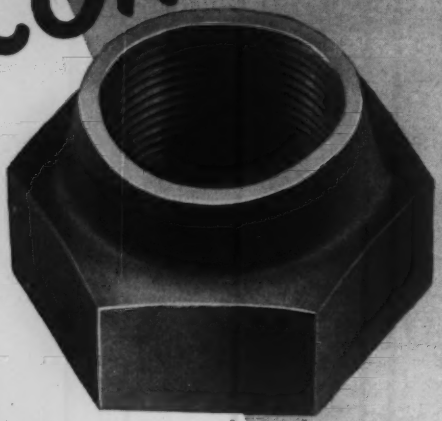
Request catalog #BL-1 or see Sweet's Product Design File.

MERCURY CLUTCHES

MERCURY CLUTCH DIVISION
of Automatic Steel Products, Inc.
1261 CAMDEN AVE. S. W., CANTON 6, OHIO

Circle 581 on Page 19

NEW CONELOK



one-piece locknut . . . *with prevailing torque*

Three sectors of the tapered portion of the CONELOK nut are preformed inwardly (Fig. 1). When the Nut is applied to a bolt, these conforming sectors are elastically returned to a circular configuration and create an inward and downward pressure which produces intimate contact between the load carrying flanks of the nut and bolt threads (Fig. 2). The shape of the cone sector displacement insures conformity with the mating bolt and maximum friction contact area. . . . The closed stress path in the locking portion of the nut and the advantageous distribution of locking pressure, produce a locking device of high fatigue life . . . and equivalent locking force is exerted at only a fraction of the stress of any slotted type locknut. CONELOK maintains its locking action through many re-applications. . . . It is adaptable to high, and low torque assemblies . . . to high torque stop-nut applications . . . and may be obtained in sizes from No. 10 to 1½", Full and Thick dimensions are "Standard".

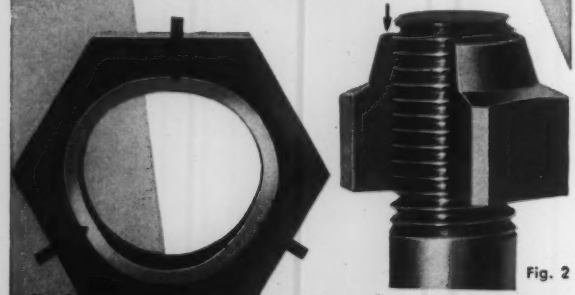


Fig. 1 Fig. 2

Send for brochure which includes complete engineering specifications.

NATIONAL MACHINE PRODUCTS COMPANY

an SPS company 4425O UTICA ROAD UTICA, MICH

MAYLINE

Your Copy of Catalog 10 Ready Now!

MAYLINE MAYLINE

May-O-Matic table fully described and illustrated. All 4-Post and pedestal style tables are portrayed and explained. Sizes and combinations of plan files are listed and shown. Various styles and construction of straightedges clearly presented for your personal selection.

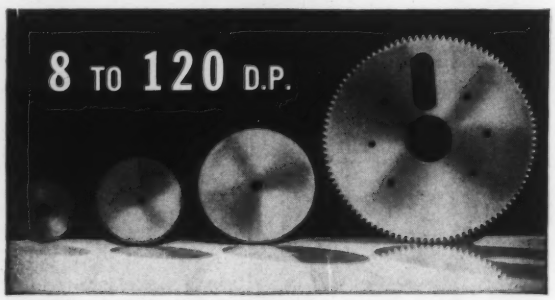
Send for your copy of catalog 10 today.

MAYLINE COMPANY, INC.

601 No. Commerce St., Sheboygan, Wisconsin

MAYLINE

Circle 583 on Page 19



LONG LIST OF STOCK GEAR DIES OFFERS YOU BIG SAVINGS!

ACCURATE STAMPED GEARS by *WINZELER* are BIG savers of time and money. Single stampings are laminated to wide faces at savings up to 60%! Further economies are made possible by a BIG range of *stock* Dies. Modern new plant, methods, and equipment now greatly increase production speed, efficiency and *economy!* Send blue prints. Tell us about your needs today. No obligation.

SEND FOR...

New list of WINZELER-made stock Gear Dies. Ask for it on company letterhead, *please!*

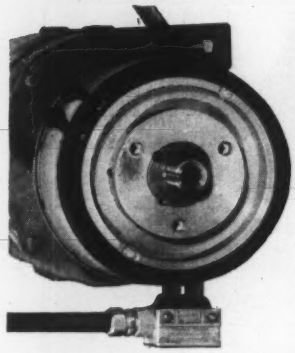
WINZELER *Stamped Gears*

WINZELER MANUFACTURING & TOOL CO.

7355 W. WILSON AVENUE • CHICAGO 31, ILLINOIS

Circle 582 on Page 19

Circle 584 on Page 19



electric clutch for remote control

Whether your equipment is controlled from 6 or 600 feet away, Warner's new Electro-Sheave drive provides split-second start-stop control from either stationary or portable push-button stations. With only two low-tension lead wires to the brushholder for supplying 90-volt actuating current, these compact clutch and pulley packages eliminate complex linkages and awkward levers on long, process-type machinery. Adapt in minutes to any standard NEMA motor shaft. Potentiometer torque control puts "feel" back into your power drives. Write for Catalog P-52.

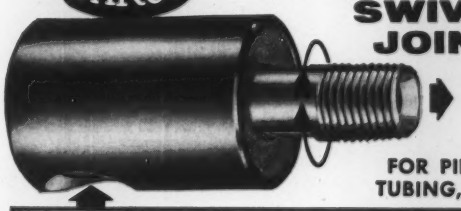
Warner Electric Brake & Clutch Co.
Beloit, Wisconsin

Circle 585 on Page 19

Here's How to Make Hose Work Better, Last Longer!

BARCO

LOW COST, BALL BEARING **SWIVEL JOINT**



FOR PIPING, TUBING, HOSE

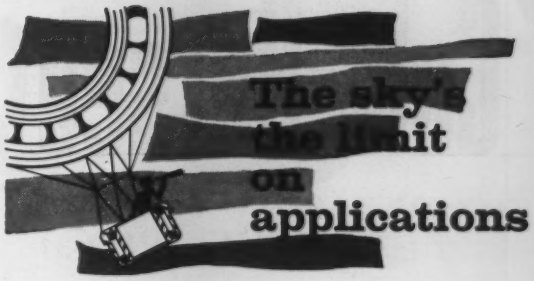
For Hydraulic or Pneumatic Service

Here is the *new* BARCO SINGLE PLANE SWIVEL JOINT that swivels in one plane only. Ideal for use as a *swivel connector:*

- **Key to Better Engineering!** Small, light, inexpensive. Very low torque under pressure. Neat, space-saving installations. Easy to position lines accurately.
- **Many Uses:** (1) To make piping or tubing movable, flexible! (2) As swivel connectors on hose to eliminate torsional working stresses and long radius bends. Longer hose life! Shorter lengths required!
- **Sealed, Unitized Construction.** Built with ball-bearings. O-ring seal. Choice of styles; sizes ¼", ⅜", ½", ¾". For service to 2,000 psi, −20° to 225°F. Other types available for higher ratings. *Ask for Catalog Sheet 406.*

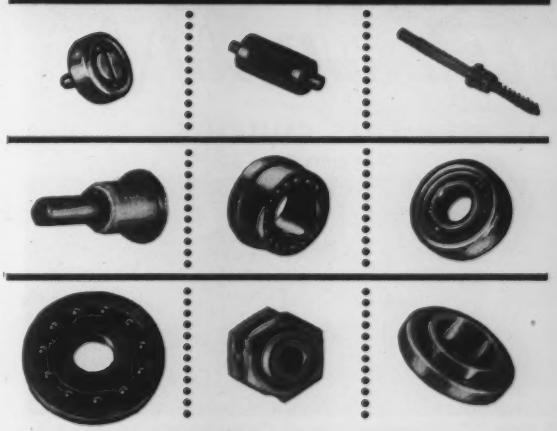
BARCO MANUFACTURING COMPANY
506K Hough Street • Barrington, Illinois

Circle 586 on Page 19



Electronic equipment . . . fishing reels . . . record players . . . office machines . . . electric mixers . . . timing motors . . . are just a few applications where low cost Hartford Vers-O-Line bearings are in wide use. These unground, semi-precision bearings offer important advantages in versatility and low cost where expensive precision bearings may now be used, but are not necessarily required. Available in single row radial or thrust, and double row Versa-Twins, they can be engineered so that parts of your product can form the inner or outer races. Hartford bearing engineers will be glad to adapt or design Vers-O-Line bearings to your exact specifications.

VERS-O-LINE
bearings by Hartford
ENGINEERED TO BE PART OF YOUR PRODUCT



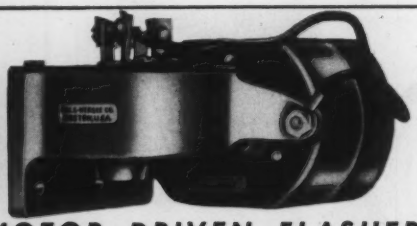
Write for comprehensive technical literature, including interesting case histories, or ask for a Hartford representative to discuss your specific requirements.

Specify **Hartford** PRECISION BALL BEARINGS

Hartford Steel Ball Co., Inc.,
91 Jefferson Avenue, W. Hartford 6, Conn.

Circle 587 on Page 19

Cole-Hersee



Reliable
ALTERNATING WARNING SIGNAL CONTROL

MOTOR DRIVEN FLASHER

FLASHERS, PILOT LAMPS & SOCKETS

PILOT OR INDICATOR LAMPS

SOCKETS STANDARD MINIATURE & PREFOCUSED

- FOR SINGLE OR DOUBLE CONTACT AND PREFOCUSED OR INDEX LAMPS.
- WITH WIRE LEADS, SOLDER SCREW, OR FLAT "QUICK-DISCONNECT" TYPE TERMINAL CONNECTIONS.
- *WITH BEAVER INTERIORS WHICH PROVIDE A CONTINUOUS AND SOLID PATH FOR CURRENT. HAS EXTERNAL NON-CURRENT CARRYING SPRINGS AND MOLDED BAKELITE INSULATORS.
- LENS COLORS IN AMBER, BLUE, CLEAR, GREEN OR RED.

WE SPECIALIZE IN DESIGNING, DEVELOPING AND MANUFACTURING PRODUCTS TO CUSTOMER REQUIREMENTS.

PILOT LAMPS ▶ PL-26 PL-19 PL-1

SOCKETS ▶ *2720 *2106 2506

* BEAVER INTERIORS

COLE-HERSEE CO.
20 OLD COLONY AVENUE, BOSTON 27, MASS.

Circle 588 on Page 19

now presenting . . .

Simplatrol

LARGER SIZES CLUTCHES & BRAKES

Diameters 4" to 12½"

5 Styles • Clutch Coupling • Electric Clutch • Combination Clutch-Brake
Electric Brake • Duplex Clutch

Three Ways Best for Automated Control

1 **Simple Design**—exclusive diaphragm is only moving part, obsoletes conventional clutch or brake made up of numerous troublesome parts.

2 **Easily Mounted**—precision machined ready for mounting, saves hours of installation labor.

3 **Dependable**—extra long life as well as quick, quiet response due to absence of moving parts which can wear and need repair.

Simplatrol Electric Clutches and Brakes simplify and upgrade machines you make or use. Ask for recommendations on Simplatrol units.

Send for new "larger sizes" folder

Simplatrol products corp.
24-S SALISBURY ST., WORCESTER, MASS.
Representation in Key Industrial Areas

606-7

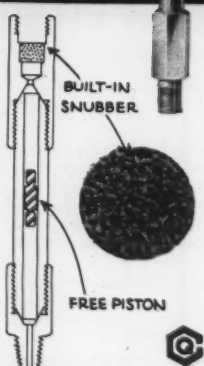
Circle 589 on Page 19

Chemiquip's

a NEW concept in PRESSURE INSTRUMENT PROTECTION

WORKER SAFETY

FLOW CHECK SNUBBER



Now, a simple, self-contained, low-cost, foolproof method of protecting valuable instruments . . . preventing the escape of noxious, toxic or flammable gases and liquids in the event of rupture in the pressure instrument system.

- **Will withstand pressures up to 30,000 psi**
- **Completely isolates instrument from the pressure transmitting media**
- **Works equally well with instruments actuated by bourdon tubes or diaphragms**

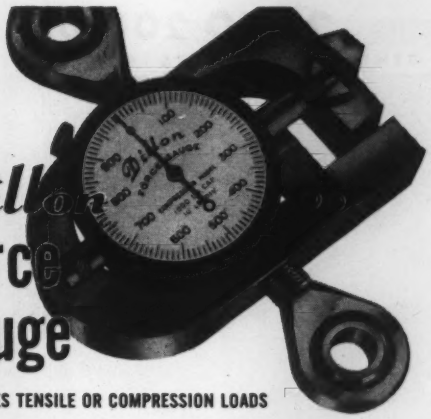
And, Chemiquip's built-in snubber

- **Prevents transmission of line surges and pulsations**
- **Never plugs or clogs**

For greater plant and/or instrument efficiency, write, wire, phone NOW for detailed Bulletin M-59.

CHEMIQUIP CO.
36 East 10th Street, New York 3
GRamercy 7-3772

Circle 590 on Page 19



Dillon Force Gauge

MEASURES TENSILE OR COMPRESSION LOADS

- Accurate to within 1% of full scale capacity.
- Jewelled dial indicator repeats perfectly.
- Shockless mechanism for rough jobs.
- Red maximum pointer registers peak loads.
- Optional switch controls mechanisms.
- Accommodates wide variety of attachments.
- Available as combination push-pull model.
- Extremely compact. Fits into "tight" spaces.
- Flexes millions of cycles without damage.

WRITE FOR FREE ILLUSTRATED CATALOG AND PRICE LIST

12 different capacities from as low as 0-10 lbs. up to as high as 0-50,000 lbs.

W.C. Dillon & CO., INC. 14564 Keswick St. Van Nuys 11, Calif.

Circle 591 on Page 19

Partners . . . . YOU AND YOUR

NO. 50 POCKET PAL

$1.00 AT YOUR LOCAL DEALER

CATALOGUE NO. 49 AVAILABLE UPON REQUEST

.030 MATTE FINISH MATHEMATICAL QUALITY DOUBLE-CURED PLASTIC

ALL HOLES SMOOTH-MILLED TO ENGRAVING MACHINE ACCURACY

ONE OF MORE THAN 30 RAPIDESIGN TIME SAVER TEMPLATES – ALL OF WHICH ARE BETTER MADE, MORE USEFUL AND LESSER PRICED

RAPIDESIGN INC.

P. O. BOX 592 GLENDALE, CALIF.

Circle 592 on Page 19

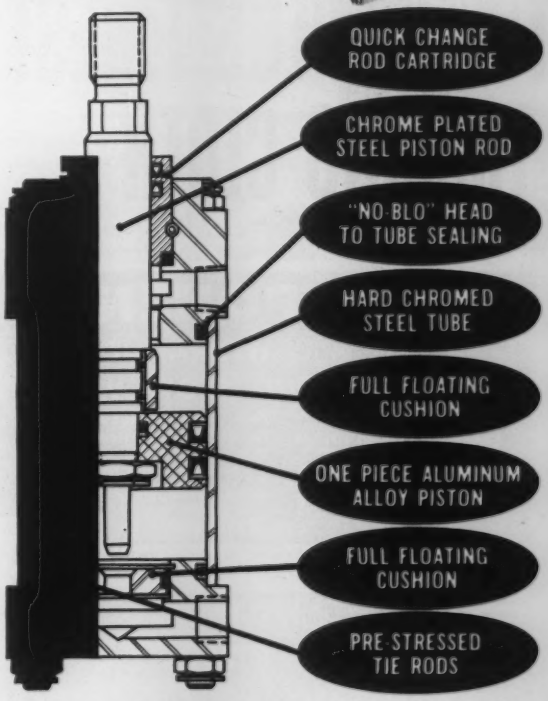
WHO'S SMILING?

YOU, WHEN **YOU** DISCOVER THE DESIGN ADVANTAGES OF . . . .

LINDBERG

SQUAREHEAD CYLINDERS

DESIGN IN LINDBERG AND . . . ADD ALL THESE FEATURES!
and many more besides!


QUICK CHANGE ROD CARTRIDGE
CHROME PLATED STEEL PISTON ROD
"NO-BLO" HEAD TO TUBE SEALING
HARD CHROMED STEEL TUBE
FULL FLOATING CUSHION
ONE PIECE ALUMINUM ALLOY PISTON
FULL FLOATING CUSHION
PRE-STRESSED TIE RODS

CERTAINLY! Your choice of mounting styles • 7 bore sizes to 6" • Built to JIC recommendations • Standardized mounting dimensions.

WANT TO SMILE AGAIN!

FOR DETAILS OF THESE AND MANY OTHER FEATURES, WRITE FOR THESE BULLETINS TODAY.

SQUAREHEAD "S" LINE—	BULLETIN S-101
2000 PSI "H" LINE—	BULLETIN H-101
HEAVY DUTY "A" LINE—	BULLETIN A-101

for fast action on "specials" tell us what you need.

LINDBERG AIR and HYDRAULIC DIV.

TEER-WICKWIRE & CO.

1877 WILDWOOD AVE. • JACKSON, MICHIGAN

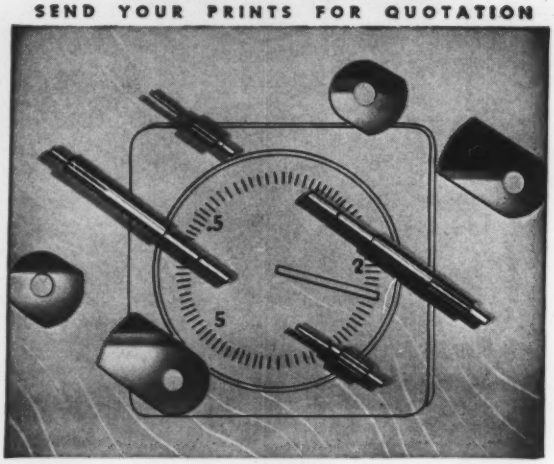
Circle 593 on Page 19

THE TREND IN DRAFTING ROOMS THROUGHOUT THE WORLD IS TOWARD IMPERIAL, THE WORLD'S FINEST TRACING CLOTH

Circle 594 on Page 19

20 TO 200 D.P.

SEND YOUR PRINTS FOR QUOTATION



SPURS • HELICALS • WORM AND WORM GEARS
STRAIGHT BEVELS • LEAD SCREWS • RATCHETS
CLUSTER GEARS • RACKS • INTERNALS • ODD SHAPES

THE *Finest* IN GEARS

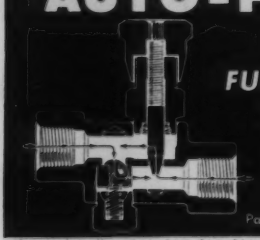
Beaver Gear Works Inc.

1031 PARMELE ST. ROCKFORD, ILLINOIS

Circle 595 on Page 19

AUTO-PONENT®

HYDRAULIC
FULL FLOW VALVES



Flow Control, Needle, Check, for HYDRAULIC Power

Model KF Flow Control Valve with Dial and Knob adjustment for direct reading and duplicating reference. Now available in Aluminum for 3000 psi.

Pat. #2,841,174

A complete line: 1/8", 1/4", 3/8", 1/2", and 3/4" female Dryseal Pipe Sizes in all models and types. Equivalent Aeronautical Tube Sizes on special order.

MINIMUM PRESSURE DROP AND POWER LOSS . . . Oversize ports and passages give maximum flow at minimum pressure drop, insure greater accuracy and response in hydraulic or large volume air cylinder control.

EASY FLOW ADJUSTMENTS under full pressure. Seal located at port to eliminate air or dirt traps. Gland structure equally effective on pressure or vacuum.

SENSITIVE, CHATTERLESS BALL CHECK . . . Patented design insures rapid ball movement to open or close at low differentials.

FORGED BODIES permit higher pressures with wide safety margins. Aluminum—3000 psi; Steel and Stainless Steel—5,000 psi. Pressure ratings based on better than 5 to 1 safety factor. All internal parts are Stainless. Write for illustrated catalog.

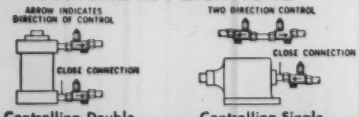
Model F Standard Flow Control Valve or Model N Needle Valve

Model KF Knob and Dial Flow Control Valve or Model KN Needle Valve.

Model PF Knob and Dial Flow Control Valve or Model PN Needle Valve for panel mounting.

Model C Check Valve for In-Line Mounting.

TYPICAL APPLICATIONS



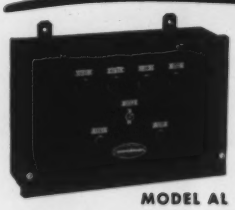
Controlling Double Acting Cylinder

Controlling Single Acting Cylinder

AUTO PONENTS INC. 2925 GRANT STREET BELLWOOD, ILLINOIS (Chicago Suburb)

Circle 596 on Page 19

MADE FOR . . . YOUR ENGINE'S *Protection*



MODEL AL

Any abnormal condition existing in your engine can be immediately brought under control by the operator with the use of Synchro-Start . . . . . .

AUTOMATIC ENGINE CONTROLS

Your engine can be protected by being automatically shut down at the first sign of low oil pressure, high water temperature, overspeed, etc.

The AL series of Synchro-Start Controls is made to fit individual requirements. Your specifications sent to us will bring immediate response.

Write for detailed information

SYNCHRO-START PRODUCTS, INC.

Since 1932

8151 NORTH RIDGEWAY AVENUE • SKOKIE, ILLINOIS

Circle 597 on Page 19

STAR STAINLESS SOCKET HEAD CAP SCREWS

Smooth and Knurled Types, Coarse or Fine Thread, Sizes 0.80 and UP. Spindle and Flat Head, Nylock also Socket Set Screws

RIGHT OFF THE SHELF®

This is just one line of Star's stock of stainless steel fastenings listed in our 1959 Catalog. STAINLESS STEEL 300 & 400 Series • BOLTS & NUTS • WASHERS • PINS • AN & MS FASTENERS • and a New STAR SERVICE—TITANIUM Bolts & Nuts to your specs.

Send for YOUR Catalog today, letterhead please.

CORROSION RESISTANT

STAR STAINLESS SCREW CO.

658 Union Blvd., Paterson 2, N. J.
Phone: Clifford 6-2300
Direct New York phone: WIsconsin 7-6310
Direct Philadelphia phone: WAlnut 5-3660

Circle 598 on Page 19

Lepel

HIGH FREQUENCY *Induction* HEATING

HARDENING
SOLDERING
ANNEALING
MELTING
BRAZING

LEPEL Electronic Tube GENERATORS—1 KW; 2½ KW, 5 KW; 10 KW; 20 KW; 30 KW; 50 KW; 75 KW; 100 KW.

LEPEL Spark Gap Converters 2 KW; 4 KW; 7½ KW; 15 KW; 30 KW.

WRITE FOR THE NEW LEPEL CATALOG . . . 36 illustrated pages packed with valuable information.

All Lepel equipment is certified to comply with the requirements of the Federal Communications Commission.

LEPEL HIGH FREQUENCY LABORATORIES, INC.
55th STREET and 37th AVENUE, WOODSIDE 77, NEW YORK CITY, N. Y.

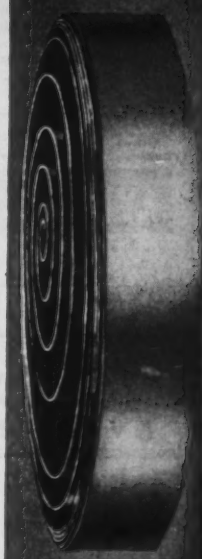
Circle 599 on Page 19

Does Your Product Demand A

SUPER SPRING?

NEW **SANDVIK 2R25 STAINLESS SPRINGS**

Give 5 To 10 Times Longer Performance



This newest addition to the Sandvik spring line is made from a premium steel for applications where performance demand outranks cost.

The steel is Sandvik's own 2R25 stainless...a special extra-tough and ultra-resilient grade. It enables the springs to withstand 5 to 10 times the windings that ordinary carbon steel springs can take. At the same time, it can endure the corrosive attacks of varying atmospheres.

Sandvik 2R25 springs are being supplied in either spiral or Sandvik's exclusive cross-curved types. Write or phone for further information on these super springs or on Sandvik's broad line of standard quality springs. Free literature, case history files and specific spring design assistance are available to you.

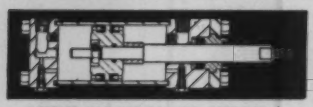
SANDVIK STEEL, INC.
Fair Lawn, New Jersey
Tel. SWarthmore 7-6200
In New York City:
ALgonquin 5-2200
Cleveland • Chicago
Detroit • Los Angeles

Circle 600 on Page 19

LYNAIR, Inc.

AIRLINE BOOSTER PUMP

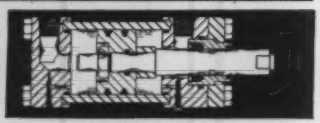
Lynair's Airline Booster was developed to boost airline pressure automatically in surge tanks or die cushions. Can be used for testing vessels at high pressure under water. By using air pressure up to 500 PSI instead of hydraulic pressure testing time can sometimes be cut in half. Booster can be furnished in ratios of 1.5 to 1 up to 6.25 to 1. Booster is completely valved—just 3 pipe connections to be made and your air pressure is automatically increased to the desired pressure.



SERIES "A" 200 PSI AIR CYLINDER

1½" to 10" bores. Eleven mounting styles available. Steel heads, shells, piston rods and tie rods. Piston rod and shell hard chrome plated. Conform to J.I.C. pneumatic standards.

1½" thru 10" bores. Ten mounting styles available. Steel heads, shells, piston rods and tie rods. Piston rod is hard chrome plated. Conform to J.I.C. Hydraulic standards.



SERIES "H" 2000 PSI HYDRAULIC CYLINDER

We are presently seeking representation in several states, including Indiana, Kentucky, Minnesota, New Jersey, Tennessee, Washington and Wisconsin.

LYNAIR, Inc. 3100 E. MICHIGAN AVE. JACKSON, MICHIGAN

Circle 601 on Page 19

ENGINEERS
AVAILABLE OR WANTED

WANTED: Mechanical Engineers, B.S. and M.S. for research work on mechanical engineering problems related to the steel industry. Salary commensurate with training and experience. Large Research Laboratory, Pittsburgh Area. Forward complete resume and salary requirements to Box 950, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

HYDRAULIC SERVO FUNDAMENTALS

by J. M. Nightingale

VOL. 1

Covers both the theoretical and practical aspects of servo system design applicable to control systems in general—hydraulic, pneumatic or combined systems.

$1.00 per copy

VOL. 2

Study of the basic servo system components and practical methods for analyzing typical servo systems.

$1.00 per copy

VOL. 3

A detailed approach to methods of improving servo system performance, quantitative design of servo systems and transient response of servo systems.

$1.00 per copy

MACHINE DESIGN
Reader Service
Penton Building
Cleveland 13, Ohio

Send me_____copies of Vol. I @ $1.00 per copy
Send me_____copies of Vol. II @ $1.00 per copy
Send me_____copies of Vol. III @ $1.00 per copy

Remittance or Company Purchase Order must be enclosed with order

NAME _____

COMPANY _____

ADDRESS _____

CITY _____ ZONE ____ STATE ____

(Add 3% to orders in Ohio to cover State Sales Tax)

Advertising Index

Abart Gear and Machine Co. 231
AC Electronics Division, The, General Motors Corporation 201
Acme Chain Corporation 172
Acro Division, Robertshaw-Fulton Controls Co. 94
Adams & Westlake 214
Airborne Accessories Corporation 192
Alemite Division, Stewart-Warner Corporation 1
AllenAir Corporation 234
Allis, Louis, Co., The 92, 93
American Insulator Corporation 45
American Machine and Metals, Inc., Hunter Spring Co. Division 87, 88
American Sealants Co. 176
American Smelting and Refining Co., Federated Metals Division 75
Ardmore Products, Inc. 43
Armstrong Cork Co. 66
Arwood Precision Casting Corporation 115
Atlantic Casting and Engineering Corporation 230
Automatic Electric 193
Automatic Steel Products, Inc., Mercury Clutch Division 237
Auto-Ponents Inc. 242

Baldor Electric Co. 205
Barco Manufacturing Co. 239
Barden Corporation, The 102
Barksdale Valves, Control Valve Division .. 232
Beaver Gear Works, Inc. 242
Bellows Co., The, Division International Basic Economy Corporation 74
Bendix-Westinghouse Automotive Air-Brake Co. 77
Bethlehem Steel Co. 98
Blood Brothers Universal Joints Division, Rockwell-Standard Corporation 114
Boehme, H. O., Inc. 176
Borg-Warner Corporation, Rockford Clutch Division 190
Boston Gear Works 229
Bound Brook Oil-less Bearing Co. ..... Inside Front Cover
Bower Roller Bearing Division, Federal-Mogul-Bower Bearings, Inc. 39
Bowser, Inc., Marketing Division 235
Bravel Products Corporation 180
Bridgeport Brass Co. 170, 171
Bridgeport Brass Co., Cored Forging Division 170
Brooks & Perkins, Inc. 234

Carpenter Steel Co., The 79
Casting Engineers Division, Consolidated Foundries and Manufacturing Corporation .. 206
Caterpillar Tractor Co. 48
Celanese Corporation of America 56, 57
Central Foundry Division, General Motors Corporation 80, 81
Chatillon, John, & Sons 222
Chemiquip Co. 240
Cherry Electrical Products Corporation 38
Chicago Rawhide Manufacturing Co., Sirvis Division 2
Cincinnati Gear Co., The 47
Circle F Mfg. Co. 30
Clark Controller Co., The 5
Cole-Hersee Co. 240
Columbia-Geneva Steel Division, United States Steel Corporation 64, 65
Consolidated Foundries and Manufacturing Corporation, Casting Engineers Division .. 206
Continental-Diamond Fibre, A Subsidiary of The Budd Co. 203
Continental Screw Co. 217
Con-Vel Division, Dana Corporation 9
Conway Clutch Co., The 185
Copperweld Steel Co., Aristoloy Steel Division 11
Copperweld Steel Co., Ohio Seamless Tube Division 71
Cramer Controls Corporation 16
Crane Packing Co. 41
Cune Engineering Corporation, The 83
Cutler-Hammer Inc. 29

Dana Corporation, Con-Vel Division 9
Dillon, W. C., & Co., Inc. 241
Dollinger Corporation 116
Driv-Lok Sales Corporation 233
Durez Plastics Division, Hooker Chemical Corporation 207

Eastman Chemical Products, Inc., Chemicals Division 210
Eastman Kodak Co., Graphic Reproduction Division 167
Eaton Manufacturing Co., Foundry Division .. 91
Elastic Stop Nut Corporation of America .. 211
Electric Products Co. 100
Electric Steel Foundry Co. 220, 221
Elgin Metalformers Corporation 189
Eriez Mfg. Co. 168
Ex-Cell-O Corporation, Rotac Division 110

Fawick Corporation, Fawick Airflex Division .. 179
Federal-Mogul-Bower Bearings, Inc., Bower Roller Bearing Division 39
Federated Metals Division, American Smelting and Refining Co. 75
Fenwal, Inc. 106
Fischer Special Mfg. Co. 44
Foundry Division, Eaton Manufacturing Co. ... 91
Funk Mfg. Co. 234

Garlock Packing Co., The 61
Gates Rubber Co., The 59
General American Transportation Co., Parker-Kalon Division 96, 97
General Electric Co. 35, 119
General Motors Corporation, The AC Electronics Division 201
General Motors Corporation, Central Foundry Division 80, 81
Gits Bros. Mfg. Co. 117
Goodrich Chemical, B. F., Co., A Division of The B. F. Goodrich Co. 76
Gray Tool Co. 196
Gries Reproducer Corporation 186
Groov-Pin Corporation 169

Hanna Engineering Works 103
Hartford Steel Ball Co., Inc. 239
Hart Manufacturing Co., The 186
Hassall, John, Inc. 174
Haynes Stellite Co., Division of Union Carbide Corporation 101
Helm Co., The 188
Heli-Coil Corporation 181
Hi-Lo Manufacturing Co. 200
Hitchiner Manufacturing Co., Inc. 196
Holo-Krome Screw Corporation, The 60
Hooker Chemical Corporation, Durez Plastics Division 207
Houdaille Industries, Inc., Manzel Division .. 236
Howell Instrument Co. 231
Hunter Spring Co., A Division of American Machine and Metals, Inc. 87, 88
Hunt Valve Co. 248
Hydromatics, Inc. 42

Illinois Tool Works, Shakeproof Division 37
Imperial Pencil Tracing Cloth Co. 242
Industrial Tectonics, Inc. 15
Industrial Timer Corporation 215
International Basic Economy Corporation, The Bellows Co. Division 74

MACHINE DESIGN

Penton Building, Cleveland 13, Ohio
Main 1-8260

BUSINESS STAFF

ROBERT L. HARTFORD
Business Manager

MARY L. CALLAHAN
Advertising Service Manager

RICHARD A. TEMPLETON
Research and Circulation Manager

BARBARA O'LEARY
Staff Assistant

ROBERT E. LESSING
Production Manager

District Offices

New York 17 .....60 East 42nd St.
RUSSELL H. SMITH, JAMES A. STANGARONE
Murray Hill 2-2581

Simsbury, Conn. .....17 Deerfield Lane
ALAN C. BUGBEE
Oldfield 8-4764

Rochester 10 .....33 Landing Rd. S.
EDWARD F. CLANCY
Greenfield 3-1223

Dresher (Philadelphia), Pa. ....1335 Harris Rd.
CHANDLER C. HENLEY
Mitchell 6-2585

Cleveland 13 .....Penton Bldg.
JACK W. WALTON, DON J. BILLINGS
Main 1-8260

Detroit 35 .....15800 West McNichols Rd.
CHARLES F. REINER
Broadway 3-8150

Chicago 11 .....520 North Michigan Ave.
HOWARD H. DREYER, ROBERT Z. CHEW
DONALD A. IVINS
Whitehall 4-1234

Los Angeles 36 .....5943 West Colgate Ave.
F. J. FULLER
Webster 1-6865

San Francisco 4 .....57 Post St.
Robert W. Walker Co.
Sutter 1-5568

Griffin, Ga. .....1106 Pine Valley Rd.
FRED J. ALLEN
Griffin 7854

Clearwater, Fla. .....1954 Jeffords Dr.
H. G. ROWLAND
(Clearwater) 33-8663

Dallas 35 .....818 Exchange Bank Bldg.
JAMES H. CASH
Fleetwood 1-4523

London, S.W.1 .....2 Caxton St., Westminster

Published by
THE PENTON PUBLISHING COMPANY

G. O. HAYS .....Chairman
R. C. JAENKE .....President
F. G. STEINEBACH ....Vice President and Secy.
F. O. RICE .....Vice President
J. P. LIPKA..Treasurer and Assistant Secretary

Also Publisher of
STEEL, FOUNDRY, NEW EQUIPMENT DIGEST, AUTOMATION

MACHINE DESIGN is sent at no cost to management, design and engineering personnel whose work involves design engineering of machines, appliances, electrical and mechanical equipment, in U. S. and Canadian companies employing 20 or more people. Copies are sent on the basis of one for each group of four or five readers. Consulting and industrial engineering firms, research institutions and U. S. government installations, performing design engineering of products are also eligible.

Subscription in United States, possessions, and Canada for home-addressed copies and copies not qualified under above rules: One year, $10. Single copies $1.00. Other countries: One year, $25. Published every other Thursday and copyrighted 1959 by The Penton Publishing Co., Penton Bldg., Cleveland 13, Ohio. Accepted as Controlled Circulation publication at Cleveland, Ohio.

BPA NEP

backtalk——

——Gesquelchen das Rumor

This is the time of year when young—and not-so-young—men's fancies turn to Detroit and the new car models. Our automotive scouts are out, as always, and although we can't reveal anything about the domestic models until

October, we can spread this word on one of the favorite imports: Der 1960 Volkswagen will *not* suffer a radical change, as has been rumored. We have information from a Black Forest elf that the VW will sport a restyled steering wheel and steering column, a front-axle stabilizer, damping to reduce engine noise in the passenger compartment, a footrest for the front passenger, and pushbutton door handles—but no major redesign.

——Can't Be Done?

A couple of fortnights ago we published a brief item wherein we quoted the opinion of two prominent space-type authorities that man will never break the light barrier and will therefore never reach other solar systems. The next mail from California brought a verbal wrist-slap from Richard Paulson, a consulting engineer and MACHINE DESIGN author. Says he, "Many Ph.D.'s in the past have made some rather dramatic statements about some subject or another, only to find that a few years later their statements didn't hold water. . . . It's like many men of not so long ago who said the horse will never be replaced by the automobile. . . . True, we will never break the light barrier with our present equipment or know-how, but this isn't what the men said."

We, of course, reported just the facts, but perhaps negative observations such as this one may have a positive effect: We have a mental picture of Mr. Paulson slamming shut his copy of MACHINE DESIGN and running to the garage to work on the first galactic rocket.

——Getting Your Bearings

Once upon an eon, a suburban cave man slipped into his leopard-skin Bermudas and stepped out onto the patio to barbecue a brace of pterodactyls. Since the usual method of cooking these birds by tossing them into the fire offended our friend, who was quite a gourmand, he came up with the idea of suspending the fowl *over* the fire, a la Boy Scout, by means of two forked branches and a straight branch passed from stem to stern through the birds. But it soon became obvious that dinner would be scorched on one side and raw on the other if it weren't turned now and again. So, this thinking cave man poked around his workship and emerged with two lengths of hollow, greasy dinosaur bone. Wedging them into the forked branches, he slipped the ends of the horizontal branch through them. The shaft spun smoothly at a slight touch from a couple of hairy fingers, and soon the happy family enjoyed a dandy meal. Not one of the hungry crowd realized, of course, that the important by-product of the proceedings was the invention of the sleeve bearing.

A good many pterodactyls have gone down the gullet since then, but the bearing principle has not changed—only materials and lubricating methods have improved. From prehistoric to present-day developments in the field, we begin, in the September 17 issue of MACHINE DESIGN, a program of articles on simplified design techniques for sleeve bearings. Although applicable to all types of these bearings, the methods and information were developed by the CBBI (Cast Bronze Bearing Institute) for cast-bronze bearings. The first article, a 34-pager, will cover 360-degree bearings for full-film, boundary, and mixed lubrication. Future pieces will discuss grooves in bearing surfaces, properties of materials, and more about lubrication. For more about pterodactyl cooking, consult Duncan Hines.

Advertising Index

Jack & Heintz, Inc., Commercial Motor Division 233
Jessop Steel Co. 72
Johns-Manville 89, 227
Johnson, Carlyle, Machine Co., The 118
Johnson Corporation, The 237

Kaydon Engineering Corporation, The 21
Keystone Steel & Wire Co. 53
Koppers Co., Inc. 78

LaSalle Steel Co. 7
Lepel High Frequency Laboratories, Inc. 243
Lindberg Air and Hydraulic Division, Teer-Wickwire & Co. 241
Linear, Inc. 174
Link-Belt Co. 63
Lord Manufacturing Co. 177
Lovejoy Flexible Coupling Co. 200
Lynair, Inc. 244

McGill Manufacturing Co., Inc. 164

Manhattan Rubber Division, Raybestos-Manhattan, Inc. 108, 109
Manzel, A Division of Houdaille Industries, Inc. 236
Mayline Co., Inc. 238
M-D Blowers, Inc. 223
Mercury Clutch Division of Automatic Steel Products, Inc. 237
Merriman Bros., Inc., Lubrite Division 202
Metals & Controls, A Division of Texas Instruments Inc. 82
Miniature Precision Bearings, Inc. 233
Minnesota Mining and Manufacturing Co., Adhesives Coatings and Sealers Division .. 95
Molded Fiber Glass Body Co. 192
Morganite, Inc. 195
Motoresearch Co. 235
Mt. Vernon Die Casting Corporation 55

National Machine Products Co. 238
National Polymer Products, Inc. 182
New Jersey Zinc Co., The 120
Norgren, C. A., Co. 99

Ohio Seamless Tube Division, Copperweld Steel Co. 71
Ortman-Miller Machine Co. 85

Packing Division, Raybestos-Manhattan, Inc. 108, 109
Parker-Kalon, A Division of General American Transportation Co. 96, 97
Parker Rust Proof Co. 104

Rae Motor Corporation 236
RapiDesign Inc. 241
Raybestos-Manhattan, Inc., Packing Division 108, 109
Reese Metal Products Corporation 214
Reliance Electric and Engineering Co. ..... Inside Back Cover
Republic Steel Corporation 112, 113
Rouland Electric Co. 58
Robbins & Myers, Inc. 68, 69
Robertshaw-Fulton Controls Co., Acro Division 94
Rockford Clutch Division, Borg-Warner Corporation 190
Rockwell-Standard Corporation, Blood Brothers Universal Joints Division 114
Rollway Bearing Co., Inc. 213
Rotac Division, Ex-Cell-O Corporation 110
Ruthman Machinery Co., The 209

Sandvik Steel, Inc. 243
Schrader, J., Co. 180
Scully-Jones and Co. 235
Sewall, E. B., Manufacturing Co. 198
Shakeproof, Division of Illinois Tool Works .. 37
Sigma Instruments, Inc. 173
Simplatrol Products Corporation 240
SKF Industries, Inc. 90
South Chester Corporation, Southco Division .. 70
Southco Division, South Chester Corporation .. 70
Southwest Products Co. 231
Spectrol Electronics Corporation 210
Stackpole Carbon Co. 199
Stacor Equipment Co. 202
Standard Pressed Steel Co., Flexloc Locknut Division 84
Stanpat Co. 206
Star Stainless Screw Co. 243
Stewart-Warner Corporation, Alemite Division 1
Struthers-Dunn, Inc. 183
Sturtevant, P. A., Co. 237
Superior Tube Co. 49, 50, 51, 52
Synchro-Start Products, Inc. 242

Taylor Fibre Co. 191
Teer-Wickwire & Co., Lindberg Air and Hydraulic Division 241
Tennessee Coal & Iron Division, United States Steel Corporation 64, 65
Texas Instruments Inc., Metals & Controls Division 82
Texas Instruments, Inc., Semiconductor-Components Division 226
Thomson Industries, Inc. 175
Timken Roller Bearing Co., The .... Back Cover
Tinnerman Products, Inc. 197
Tomkins-Johnson Co., The 107
Torrington Co., The 13
Torrington Co., The, Specialties Division 194
Torrington Manufacturing Co., The 111
Trabon Engineering Corporation 54
Twin Disc Clutch Co. 32, 33

Unicast Corporation 46
Union Carbide Corporation, Haynes Stellite Division 101
United Electric Control Co. 236
U. S. Axle Co., Inc., The 67
United States Steel Corporation, Subsidiaries 64, 65
United States Steel Export Co. 64, 65
United States Steel Supply Division, United States Steel Corporation 64, 65

Veeder-Root, Inc. 224, 225
Viking Pump Co. 216
Vlier Engineering Corporation 62

Wapakoneta Machine Co., The 40
Warner Electric Brake & Clutch Co. 239
Washington Steel Corporation 204
Waterman Engineering Co. 27
Wayne Pump Co., The, Industrial Division .. 200
Webster Electric, Oil Hydraulics Division 105
Wheelock, Lovejoy & Company, Inc. 219
White, S. S., Industrial Division 73
Wiegand, Edwin L., Co. 208, 209
Winsmith, Inc. 212
Winzeler Manufacturing & Tool Co. 238
Wood's, T. B., Sons Co. 187
Wyman-Gordon 86

Engineers Available or Wanted 244

TIPS AND TECHNIQUES

VOLUME I

DRAFTING AIDS

- Helpful Drawing Techniques
- Simplifying Drafting Practices
- Protecting Prints and Drawings
- Modifying Equipment for Extended Use
- Getting the Most from Drawing Instruments

Helpful Tips and Techniques that apply to drafting practices, are now available in this one-volume reference. It contains 32 pages of practical drafting shortcuts every engineer can use.

$1.00 a copy

Order from

MACHINE DESIGN
READER SERVICE
Penton Building
Cleveland 13, Ohio

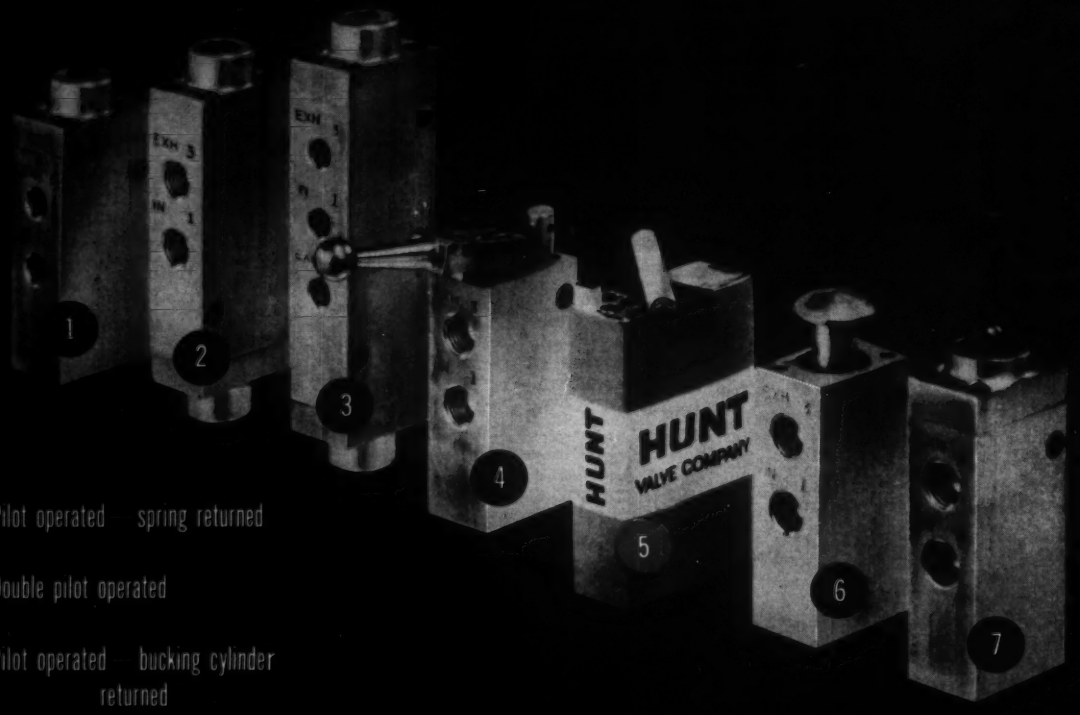
(Remittance or Company Purchase Order must be enclosed with order.)

Circle 602 on Page 19→

another

the TRIM LINE

by **HUNT**



1. Pilot operated spring returned
2. Double pilot operated
3. Pilot operated bucking cylinder returned
4. Lever operated
5. Reserved for valve actions to come
6. Palm-button operated
7. Ball actuated

An unbelievably small valve with a long, long life

Priced economically . . . that's TRIM LINE, Hunt's newest valve in a series of new valve designs.

The TRIM LINE is available in 3-way and 4-way actions. Furnished tapped for either ⅛" or ¼" pipe connections.

Designed for installations where space is limited, TRIM LINE is a quality valve you can depend on to work right . . . and to LAST. Just replace the "O" rings and it works on and on and on.

For complete details write to . . .

HUNT VALVE COMPANY • SALEM, OHIO, U.S.A.

HUNT *Quick-As-Wink* AIR & HYDRAULIC CONTROL VALVES

INTRODUCING AN ALL ELECTRIC, VARIABLE SPEED DRIVE FOR UNDER $220.* THE FRACTIONAL hp. V★S Jr.

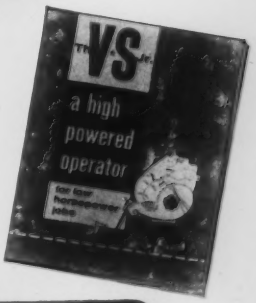
Now you can gain the efficiency of stepless speed changes for smaller machines. The new fractional V★S Jr. puts complete machine control at your operator's fingertips, for less than $220.*

The fractional V★S Jr. will vary drive motors speeds from 215 thru 1725 rpm. Speeds can be changed through this 8:1 range by a simple turn of the selector dial. Speed changes can be made while the machine is operating or pre-selected before starting.

This packaged drive provides start, stop and stepless speed changes from in-plant a-c. power. Jog, reverse, and braking functions are available for more flexibility. The fractional V★S Jr. is available from ⅛ thru ¾ hp. in all enclosures with standard or gearmotor, and is a new addition to the integral V★S Jr. line, 1 thru 4 hp.

*⅛ hp. drive complete with motor, controls, and operators panel.

For complete details contact your local Reliance representative or write today for this new illustrated bulletin D-2507.



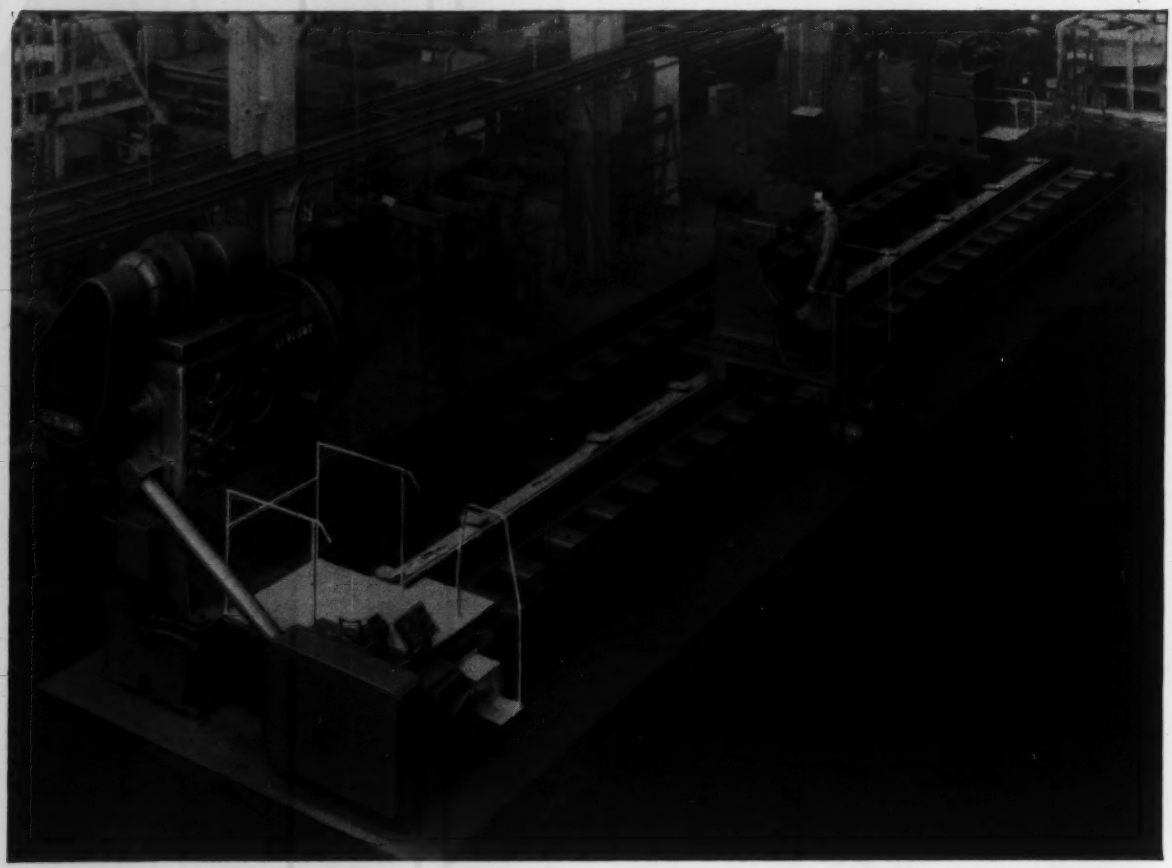
RELIANCE ELECTRIC AND ENGINEERING CO.

DEPT. 289A CLEVELAND 17, OHIO
Canadian Division: Toronto, Ontario
Sales Offices and Distributors in principal cities

MASTER

REEVES

Circle 402 on Page 19



First U.S. double-bed lathe... Le Blond's huge "Admiral"... assures spindle rigidity with Timken® bearings

IT'S a giant! . . . this lathe built by R. K. Le Blond Machine Tool Co. Named the "Admiral", it's the first U.S.-built double-bed lathe. And it weighs 75 tons, is 54 ft. 6 in. long, 120 in. wide. To maintain spindle rigidity under 50,000 lb. line load, Le Blond mounts it on Timken® tapered roller bearings. And for extra quality, the lathe ways are made of Timken 91140 steel. Le Blond uses Timken bearings to get:

1) *Special precision.* Timken bearings are made specifically for precision spindle applications.

2) *Extra load-carrying capacity.* Full-line contact between rollers and races gives Timken bearings extra capacity and their tapered design lets Timken bearings take *both* radial and thrust loads. They hold the spindle rigid.

3) *Extra toughness.* The bearing's heart—the steel—is nickel-rich. And to be sure it's the finest we make it ourselves . . . America's only bearing maker that does.

4) *Virtually eliminate friction.* Timken bearings are designed and precision-made to roll true.

For machines that perform better at lower cost, be sure the ones you buy or build are equipped with Timken tapered roller bearings. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO". *Makers of Tapered Roller Bearings, Fine Alloy Steels and Removable Rock Bits.*

This symbol on a product means its bearings are the best.

WHEN YOU BUY TIMKEN® BEARINGS YOU GET...

1. Quality you can take for granted
2. Service you can't get anywhere else
3. The best-known name in bearings
4. Pace setter in lower bearing costs

BETTER-NESS rolls on

TIMKEN®

First in bearings for 60 years

tapered roller bearings

Circle 403 on Page 19